NASA Contractor Report 166616

NASA-CR-166616-PT-2
19860003886

Mathematical Analysis Study for Radar Data Processing and Enhancement

Part II: Modeling of Propagation Path Errors

Robert James and James D. Brownlow

Contract NAS2-11491
August 1985

National Aeronautics and
Space Administration

NASA Contractor Report 166616

Mathematical Analysis Study for Radar Data Processing and Enhancement

Part II: Modeling of Propagation Path Errors

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Prepared for
Ames Research Center
Dryden Flight Research Facility
Edwards, California
under Contract NAS2-11491

1985

National Aeronautics and
Space Administration
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MATHEMATICAL ANALYSIS STUDY
FOR
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PART II - MODELING OF PROPAGATION PATH ERRORS

1.0 INTRODUCTION

In accordance with requirements set forth in contract NAS2-1149, propagation path errors were modeled using three refraction correction methods.

1. The gradient refraction method (A900 computer)

2. The spherical slab correction method (Varian 73 computer)

3. The White Sands (Pearson) method (Cyber 7028 computer)

Each of these methods is described briefly below. For detailed mathematical algorithms used by each, refer to reference 8 for the gradient refraction solution, to reference 9 for the spherical slab solution, and to reference 10 for the Cyber solution.

Solutions from each of these methods were obtained for ranges out to 150 or more nautical miles and for altitudes up to 100,000 feet. Results were compared with tabulated data from high-precision refraction correction algorithms described in reference 9. Also analyzed were propagation path effects using five reference atmospheres selected to cover the extremes of weather conditions at Edwards.

1.1 Definition of terms

The term 'exact' is used in reference to correction methods which use iterative processes in which the accuracy is limited only by the speed and precision of the computer, and, of course, by the knowledge of the atmospheric composition. If the latter is known, then with sufficient time and computer precision, any specified degree of accuracy can be obtained. These solutions are literally an integration process in which delta-t is taken closer and closer to zero to obtain an ever more accurate solution.

The term 'approximate' is applied to empirically-determined methods which attempt to obtain quick solutions that are reasonably close to the results from the 'exact' methods or to experimental data that has been accumulated as a result of long term observations. The term 'error' is applied to the difference between the tested solution and the 'exact'

solution being used as a reference, or to the difference between the tested solution and experimental data.

It should be noted that the results of 'exact' solutions are only as good as the estimates of the atmospheric composition, and, therefore, may be far from exact on any given day when the atmosphere is not well behaved. Therefore, the accuracy of any of the tested refraction techniques must be accepted with that limitation.

The symbol 'n' refers to index of refraction (n = 1 for a vacuum). The symbol 'N' refers to refraction modulus, refactivity, or modulus of refraction all of which equal n - 1. The term N-units applies to the value N times 10 to the 6th power. For example a refractivity of 0.0003307 would be 330.7 N-units.

2.0 DESCRIPTION OF REFRACTION METHODS ANALYZED

2.1 The Gradient Refraction Correction Method

The gradient refraction method falls into the category of an 'exact' solution. In the gradient method, two rays are incrementally projected outward from the source, starting at the measured elevation angle. The amount of bending in each incremental segment is determined from the refractivity gradient computed perpendicular to the direction of the ray travel. This causes a velocity differential between the upper and lower rays so that one ray (usually the upper) will travel slightly farther in the same time increment. This determines the amount of rotation in the wave front. At each new iteration, the rays are projected perpendicular to the angle of the new wave front as computed during the preceeding iteration. At each iteration step, the range remaining is decreased by the average refraction corrected path length of the ray within the cell. The values for refractivity and the refractivity gradient at the midpoint position of each segment or cell can be computed from a mathematical relation (such as when using exponential refractivity) or from a mathematical curve fit to real-world data.

Gradient refraction was developed by GMD Systems and was reported in reference 8. It is believed to be superior to the conventional Snell's law approach since it works essentially with small angles, thereby eliminating register saturation conditions that accompany most Snell's law solutions, and it can achieve accuracies equivalent to other 'exact' solutions using fewer iterations and without the need for a computer with an exceptional word length. Furthermore, the algorithms were designed to yield the maximum possible accuracy at very low (or even negative) angles.

2.2 The Spherical Slab Refraction Correction Method

The spherical slab solution method is an 'approximate' solution. It computes range and angle corrections based on surface refractivity using an exponential lapse rate. Of the several approximation methods in common use, the spherical slab solution was selected for use by JSC early in the Space Shuttle program because it provided slightly better results than other 'approximate' solutions tested.

With the spherical slab method, a slab height, H*, is computed for each solution. Everywhere below the slab, the refractivity is the same as the surface value. Everywhere above the slab, the refractivity is zero (no refraction). Based on the measured range, Rm, and the measured elevation angle, Em, a number of empirical computations are performed to determine the slab height such that a ray projected from

the source at angle Em will travel in a straight line until reaching the surface of the slab. At that point, a single Snell's Law refraction will bend the ray so that it passes approximately through the target point. Needless to say, the key to this method is in the determination of the proper slab height which will cause this to occur for a particular combination of Rm and Em values. Reference 9 evaluated 13 empirical relations for calculation of the elevation correction, and 5 for the calcuation of the range correction. The selected elevation correction is claimed to have a maximum error of 24.4 percent at 0 degree elevation, and negligible error above about 10 degrees.

2.3 The Cyber Refraction Correction Method

The third method was developed at White Sands Missile Range in 1958. It was intended to provide a rapid data reduction process that would eliminate the need for lengthy processing of atmospheric profile data. It's design goals were to provide results which would 'hold' for elevation angles from 1 degree to 90 degrees over a range of 500 to 200,000 yards. The solution assumes an exponential lapse rate from the surface to an altitude where the refractive index is essentially constant over the entire year (about 24,000 feet MSL at White Sands). The elevation correction uses two constants Kle and K2e. Kle is computed from the value of surface refractivity. Using the computed value of Kle, a corresponding value of K2e is obtained from a table of precomputed constants by using linear interpolation methods. The value of the elevation angle correction is then determined by the relation:

$$Ec = (Kle\ Rm \cos Em)/(K2e\ Rm \sin Em)$$

A range correction of the same form is provided in reference 10, however no range correction is used in the Cyber program.

3.0 MODELING METHODS USED IN THIS ANALYSIS

The modeling of results from each of the three methods was accomplished in two phases. The first phase compared the solutions from each of the three methods with tabulated results from an 'exact' solution described in reference 9. This solution was based on a JSC ray-tracing technique in which each result was generated in double precision (28 decimal digits) on a CDC Cyber 74 computer. Results provided in the tables in reference 9 were based on 50,000 iterations for Em of 0 degrees, 5000 iterations for values of Em from 0.5 to 2.5 degrees, and 500 iterations for values of Em of 3 degrees or greater. The JSC ray-tracing solutions uses a conventional Snell's Law approach which subdivides the atmosphere into concentric shells. Refractivity within each shell is a constant value. Bending occurs as the ray crosses each shell boundary. Additional accuracy is obtained by increasing the number of shells, and hence the number of iterations, used for each solution. Obviously, refractivity values within the shell structure can be based on a mathematical relation between refractivity and altitude, or on real world values quantitized to the altitude intervals of the shells. Probably the greatest disadvantage of this method is that it works with large angles and requires a large word length to prevent register saturation.

The tables provided in reference 9 were compiled specifically for the purpose of determining the accuracy of newly proposed 'approximate' refraction correction methods, and were based on the modulus of refraction being an exponential function of altitude. Note that the modulus of refraction in the real world is never exactly exponential; however, the purpose of the JSC document was not to define the nature of the atmosphere but to determine how well individual refraction methods would yield accurate results with a completely defined, ideal exponential atmosphere. The document also does not attempt to compute the modulus of refraction for any specific psychrometric conditions, but provides results for three separate values of refractivity. In short, if the sea-level refractivity for the r-f energy is the same as the value given in any one table, and, if the atmosphere were ideally exponential in nature, then the results from other solution methods should match the 'exact' values given in the tables.

In the second phase, two of the methods were compared against a third to determine how much difference would result when approximate solutions (using only surface refractivity values) were compared with a high-accuracy solution which used different vertical profiles, representative of both typical and extreme atmospheric compositions. The atmospheric compositions examined were:

1. EHA-75 hot day atmosphere

2. ECA-75 cold day atmosphere

3. A typical cold moist morning atmosphere

4. A typical warm moist morning atmosphere

5. A typical hot day afternoon atmosphere

Although items 1 and 2 above do not include the amount of water vapor present at the various altitudes, estimates of these values were supplied by NASA in terms of dew point temperatures to accompany the temperature and pressure profiles.

4.0 PHASE I - COMPARISON WITH JSC RESULTS

During Phase I of the modeling of the three refraction methods, the measured range and measured elevation values from the JSC tables were used as inputs to all three solution methods. The JSC tables are structured such that measured range values are provided for specific measured elevation values of 0, 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, 6, 7, 8, 9, 10, 12, 14, 16, 18, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, and 90 degrees. Separate tables are provided for target true altitudes of 1000, 2000, 5000, 10,000, 20,000, 50,000, and 100,000 meters for three separate refractivity values: 0.0002550, 0.0003307, and 0.0003860. This analysis called for ranges out to 150 nautical miles and altitudes up to 100,000 feet. Therefore, tabulated values are provided in appendix A to appendix C. Appendix A contains values for target altitudes of 1000, 2000, 5000, 10,000, 20,000, 50,000, and 100,000 meters obtained using a sea level modulus of refraction of 0.000255; appendix B provides values for the same target altitudes using a modulus of refraction of 0.0003307, and appendix C provides the same data for a modulus of refraction of 0.000386. In these tables, the target horizontal range goes from 0 out to about 640 nautical miles.

The headings on each of the tables show the sea level modulus of refraction, the scale height, and the target altitude. The first two columns in the tables are the input data, the measured elevation and range values given in the JSC tables. This is followed by the corrected elevation and range values as computed by the gradient solution, the corrected elevation values computed by the Cyber (White Sands) solution, and the corrected elevation and range values computed by the Varian (spherical slab) solution. The next item in the table is the geometric altitude which would be obtained with no refraction, followed by the altitudes as computed from the gradient, Cyber, and spherical slab solutions. Note that the Cyber solution contains no range correction.

Since it is difficult to assimilate all of the data contained in these tables, data plots were made for target altitudes of 2000 meters (6562 feet), 5000 meters (16,404 feet), 10,000 meters (32,808 feet), and 50,000 meters (164,042 feet). These are provided for each of the three values of surface refractivity used in Phase I of the modeling analysis.

4.1 Comparison of Solutions for Nsl of 0.0002550.

Plots for a surface refractivity (Nsl) of 0.0002550 are provided in figures 4-1(a) to 4-1(d). The gradient solution, shown as a solid line, yields altitude values whose maximum 'error' is on the order of 0.1 percent below 0.5 degree; dropping to about 0.01 percent by 5 degrees. The altitude 'error' in the spherical slab solution method, shown by the short dashed line, has a maximum value of about 5.6 percent for angles under 1 degree; dropping to under 1.0 percent around 2 degrees elevation and to about 0.05 percent by 5 degrees elevation. The Cyber method, according to reference 10, is limited to elevation angles above 1 degree. Discounting errors in angles below 1 degree, the maximum 'error' in the Cyber solution is on the order of 0.45 percent decreasing to about 0.1 percent by 4 to 6 degrees elevation angle, depending on the target altitude. Although 'errors' for elevation angles above 30 degrees are not shown on the plots, all converge to the correct altitude except for the Cyber solution which has a small error remaining at 90 degrees elevation angle because no range correction is made.

In terms of actual altitude 'errors' the gradient solution has its maximum 'error' of 27 meters (88.6 feet) in the derivation of altitude for the 50,000 meter (164,041 foot) target being tracked at 0 degree elevation angle. The spherical slab 'error' for the same tracking condition is 1,752 meters (5,748 feet). By the time the target has reached 1 degree elevation angle the 'error' in the gradient solution has dropped to 2 meters (6.6 feet), the 'error' in the spherical slab solution has dropped to 499 meters (1637 feet), and the 'error' in the Cyber solution is 769 meters (2522 feet). At a 5 degree elevation angle, the three 'error' values are 0 meters, 50 meters (164 feet), and 56 meters (184 feet) respectively.

For a target at 10,000 meters (32,808 feet) altitude, the 'errors' in the three solution methods are: for 0 degree elevation angle, 8 meters (26.2 feet) for the gradient solution and 607 meters (1991 feet) for the spherical slab solution; for 3 degrees elevation, 1 meter (3.28 feet) for the gradient solution, 11 meters (36 feet) for the spherical slab solution, and 28 meters (92 feet) for the Cyber solution; and for 10 degrees elevation, 0 meter for the gradient solution, 1 meter (3.28 feet) for the spherical slab solution, and 5 meters (16.4 feet) for the Cyber solution.

Tabulated data for this test condition are provided in appendix A.

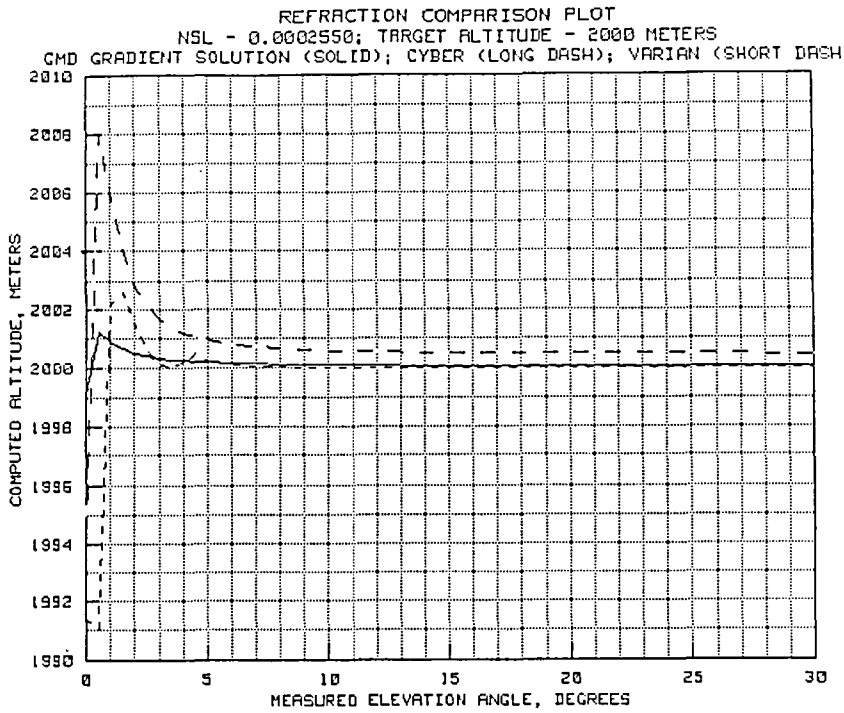

Figure 4-1(a). Plots for target at 2000 meters altitude.

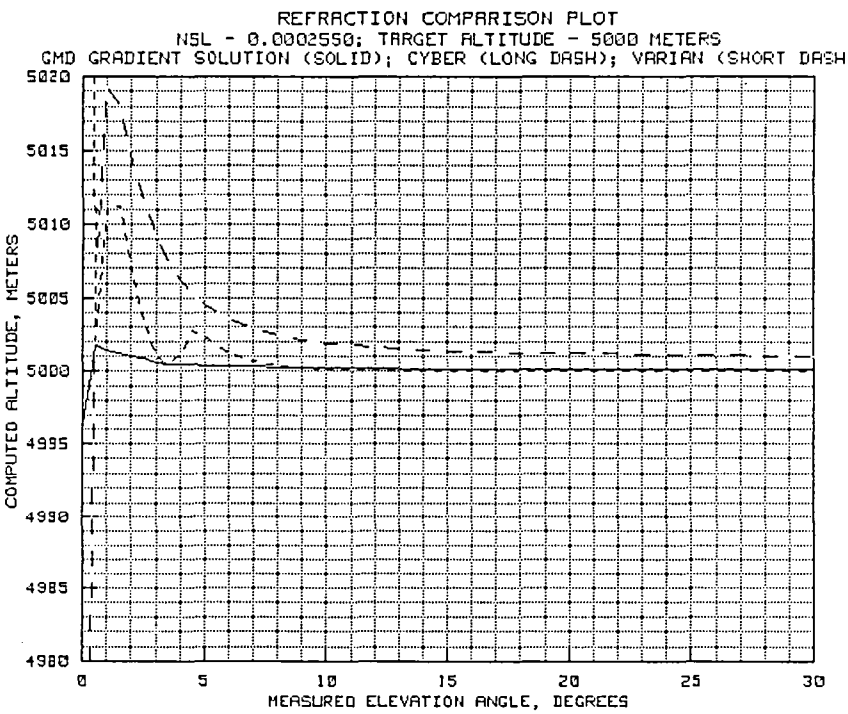

Figure 4-1(b). Plots for target at 5000 meters altitude.

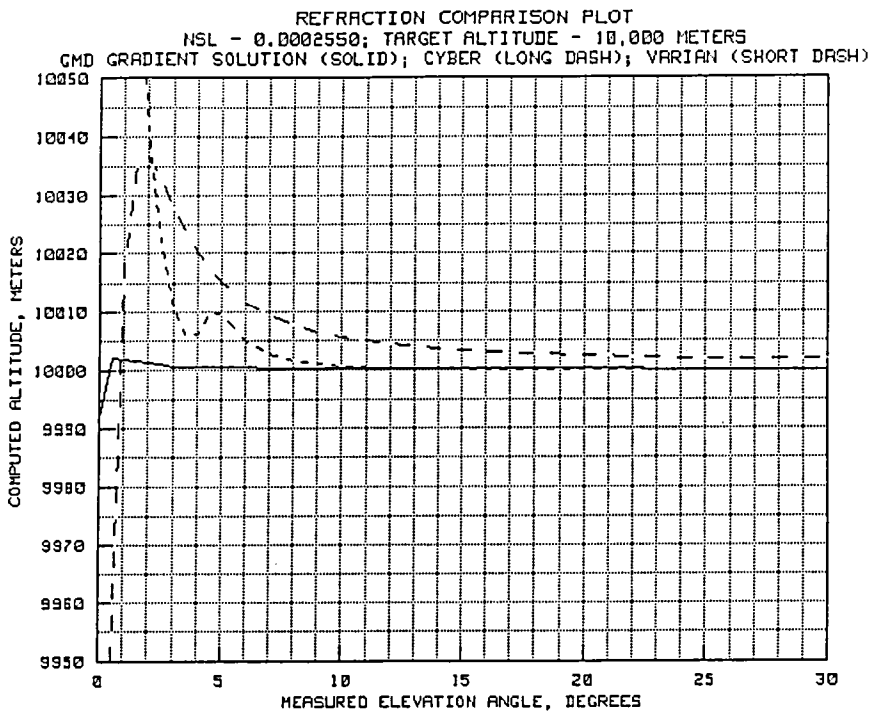

Figure 4-1(c). Plots for target at 10,000 meters altitude.

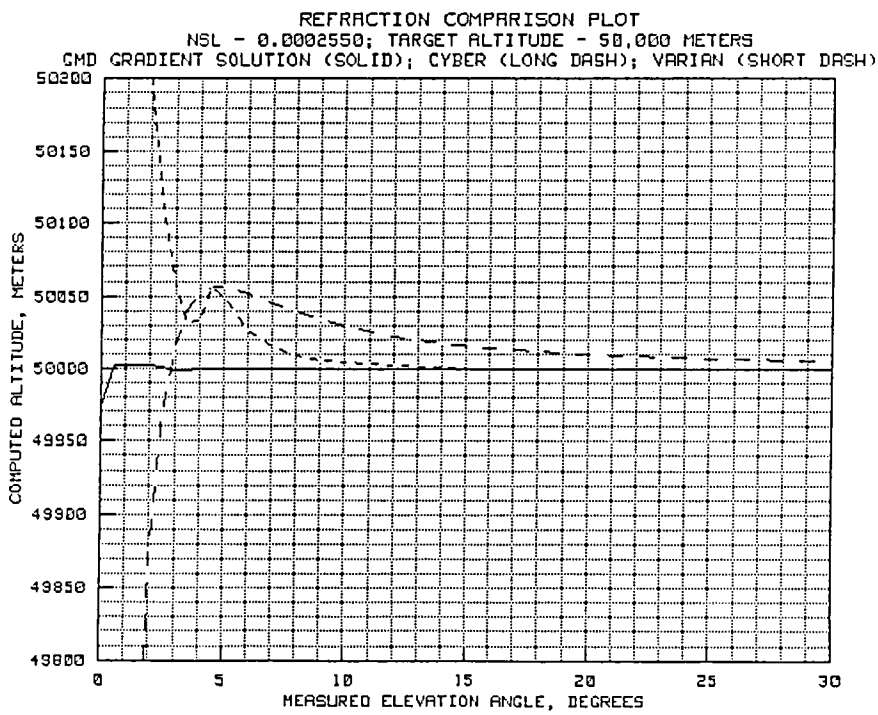

Figure 4-1(d). Plots for target at 50,000 meters altitude.

4.2 Comparison of Solutions for Nsl of 0.0003307.

Figures 4-2(a) to 4-2(d) show the same plots for a sea level refractivity of 0.0003307 and a scale height of 6631.54 meters (21757.0 feet). This value is probably the closest to a typical Edwards day. The 'errors' in all three methods seem to be slightly greater with the increased refractivity. For the gradient solution, the error for the 0 degree elevation track of a target at 50,000 meters (164,041 feet) is 46 meters (150 feet) or about 0.1 percent. By 0.5 degree elevation, the 'error' in the gradient solution has decreased to about 2.5 meters (8 feet) or less. Above 3 degrees elevation, the 'error' is below 0.003 percent for all altitudes.

For the same refractivity value, the spherical slab solution yields altitude results that have an 'error' of 1799 meters (5,902.2 feet) for a target at 50,000 meters (164,041 feet) being tracked at a 0 degree elevation angle. Also note that the spherical slab results are highly erratic at the lower elevation angles for all altitudes. For the same 50,000-meter target, the errors in the spherical slab solution decrease to a minimum at around 3 to 3.5 degrees and then again increase, hitting a second peak about 4 to 6 degrees. For a target at 2000 meters (6562 feet), the secondary peak yields an 'error' of only 1 meter (3.28 feet), however, for a target at 50,000 meters (164,041 feet) the secondary peak causes an altitude 'error' of 58 meters (190 feet). Above 10 degrees elevation angle, the errors in the spherical slab solution drop below 0.01 percent at all altitudes.

For the same refractivity conditions the Cyber solution yields 'errors' that are equivalent to 1464 meters (4803 feet) for the 50,000 meter (164,041 foot) target being tracked at a 1 degree elevation angle. The 'error' on the same high altitude target drops to 50 meters (164 feet) by the time the elevation angle has increased to about 3 degrees, then slowly diminishes to about 2 meters (6.5 feet) by the time the target is overhead.

Tabulated data for this test condition are provided in appendix B.

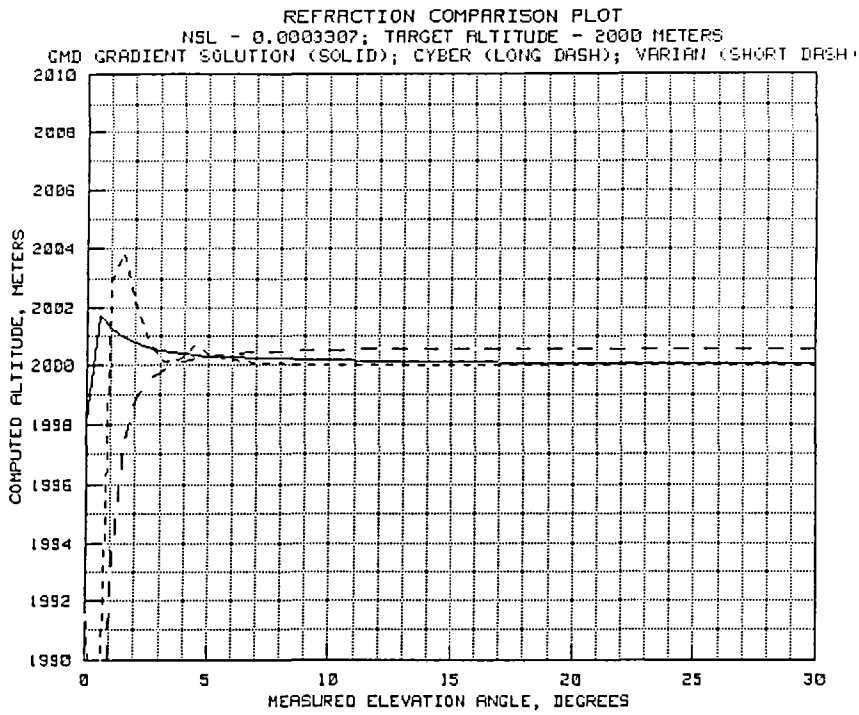

Figure 4-2(a). Plots for target at 2000 meters altitude.

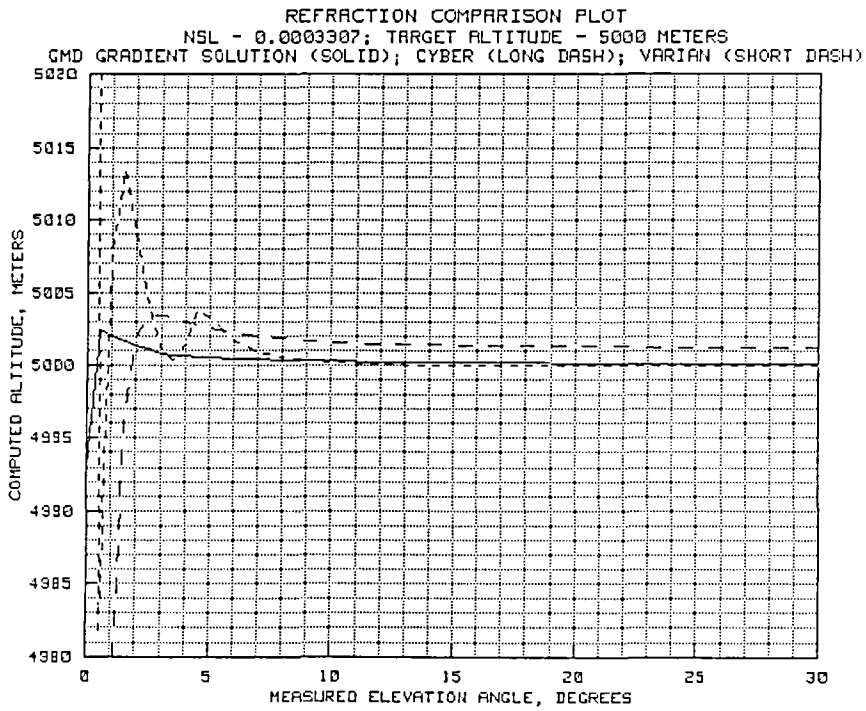

Figure 4-2(b). Plots for target at 5000 meters altitude.

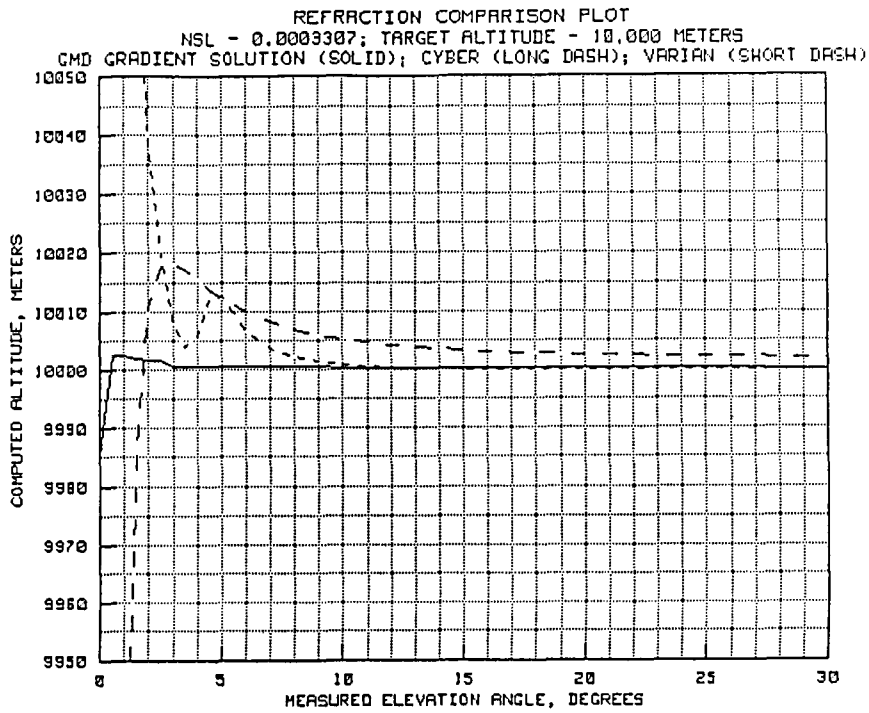

Figure 4-2(c). Plots for target at 10,000 meters altitude.

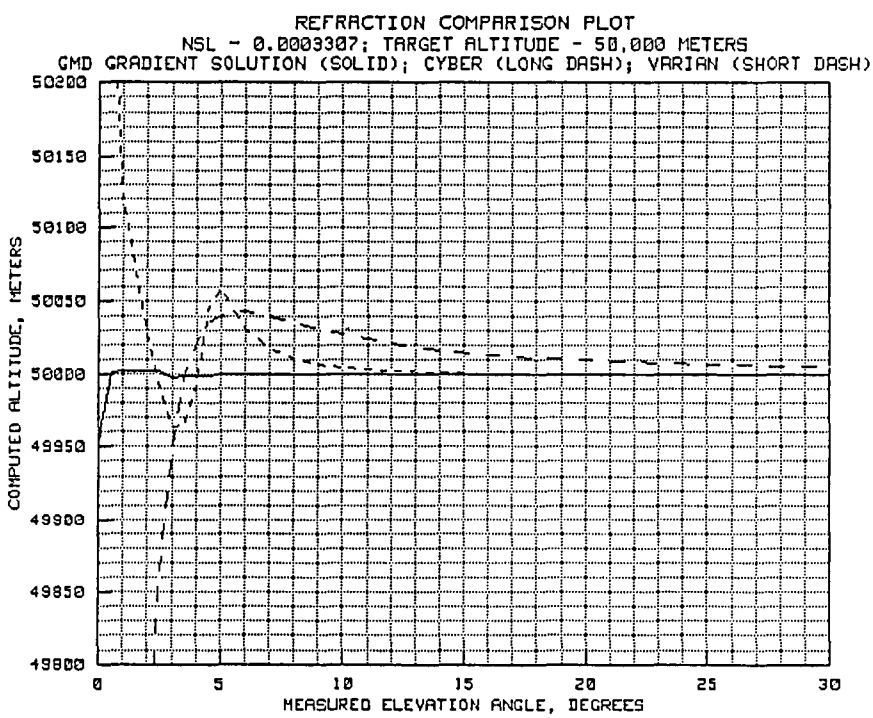

Figure 4-2(d). Plots for target at 50,000 meters altitude.

4.3 Comparison of Solutions for Nsl of 0.0003860.

Values for the third JSC test condition with a sea level refractivity of 0.000386 are shown in figures 4-3(a) to 4-3(d). Note that the Cyber data is not included in this plot, because the sea-level refractivity value exceeds the table limits used in the Cyber program. Again, the 'errors' in each method increase somewhat as the refractivity value increases. For the 50,000 meter target being tracked at a 0-degree elevation angle, the gradient solution shows an 'error' of 68 meters (223 feet) while the spherical slab solution shows an 'error' of about 1510 meters (4954 feet). For a target at 10,000 meters (32,808 feet) altitude, the maximum 'error' with the gradient solution is 23 meters (75 feet) at 0 degrees elevation angle. For the same target and the same elevation angle, the spherical slab solution shows an 'error' of about 842 meters (2762 feet). By the time the elevation angle reaches 3 degrees, both solutions yield 'errors' on the order of 1 meter (3.28 feet).

As in the other cases, the spherical slab results are very erratic when the elevation angle is low.

Tabulated data for this test condition are provided in appendix C.

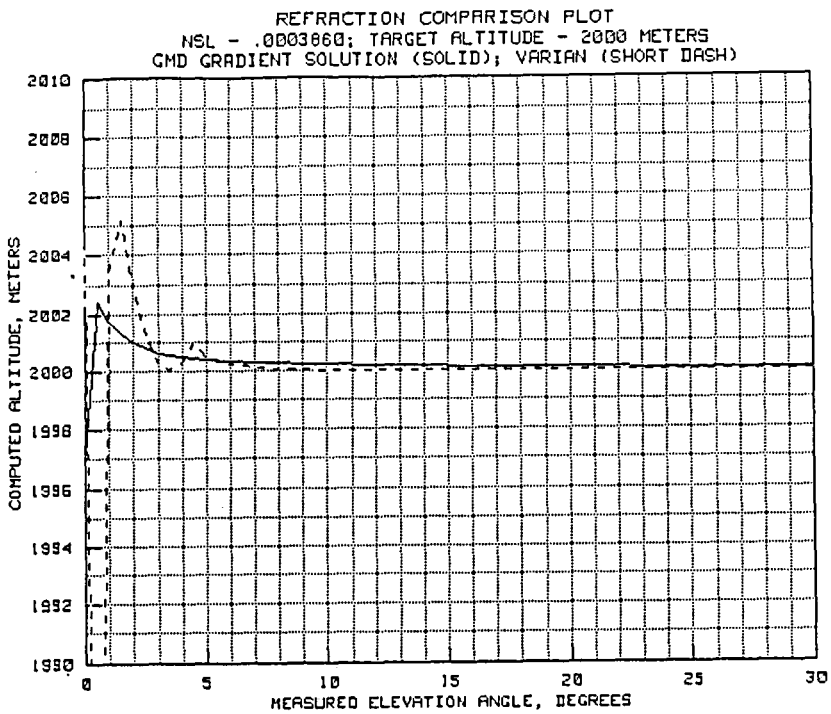

Figure 4-3(a). Plots for target at 2000 meters altitude.

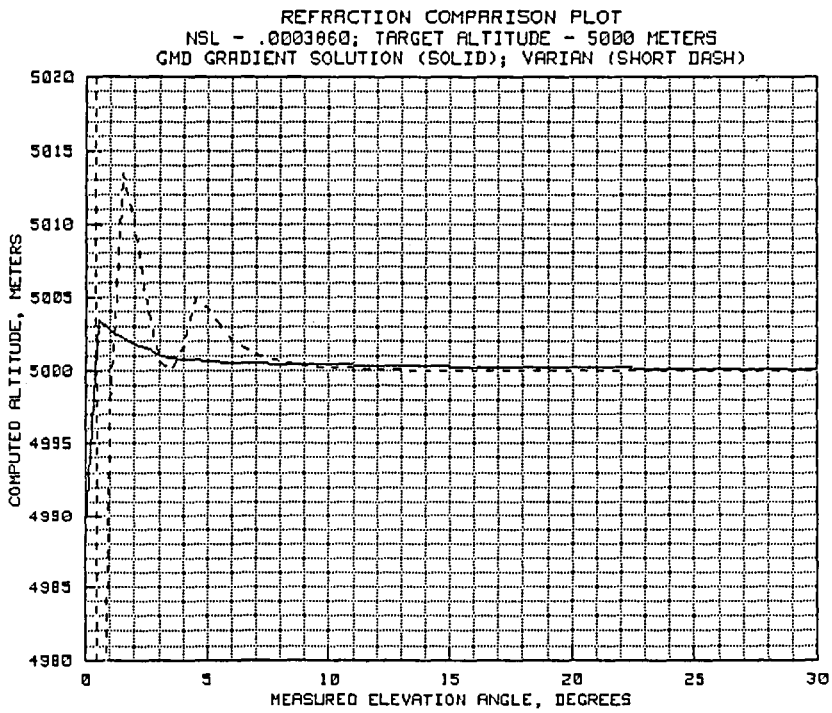

Figure 4-3(b). Plots for target at 5000 meters altitude.

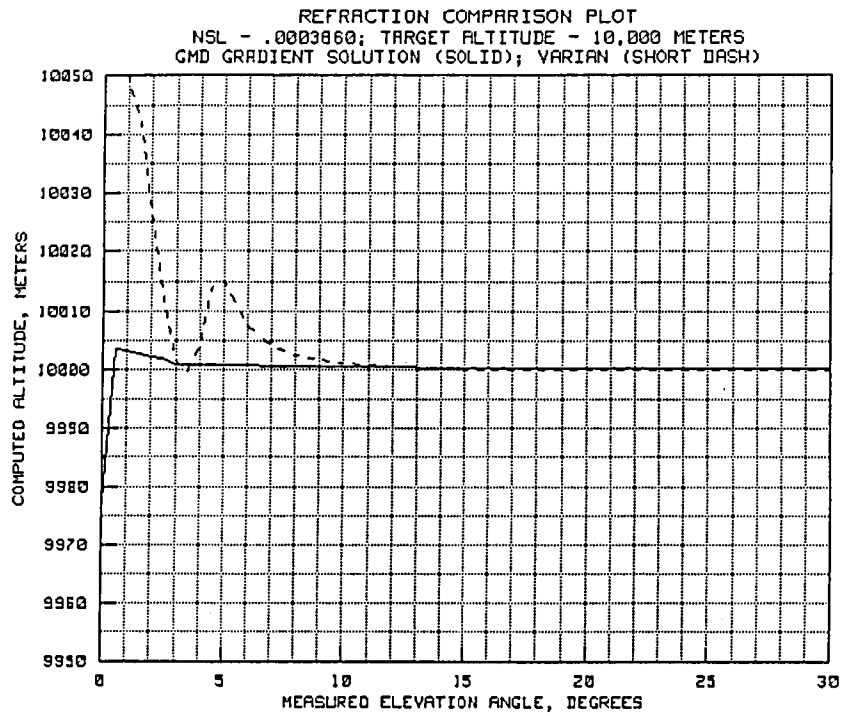

Figure 4-3(c). Plots for target at 10,000 meters altitude.

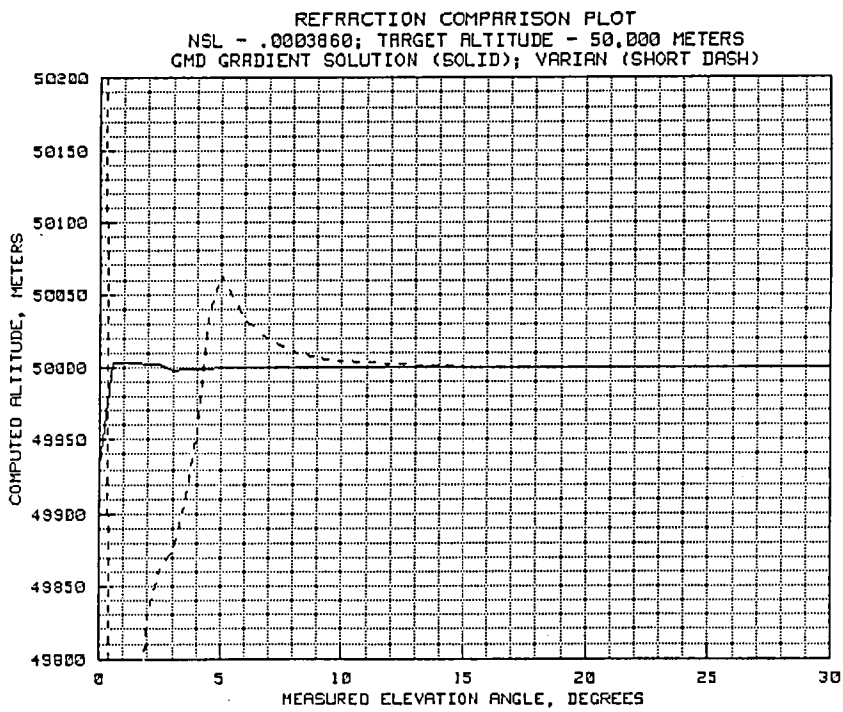

Figure 4-3(d). Plots for target at 50,000 meters altitude.

4.4 Results of the Phase I Analyses

The analyses of all three refraction methods currently in use at Dryden indicates that, when compared with data derived from an 'exact' method used for comparison purposes by JSC, the gradient solution used on the A900 computer at the radar site yields the best agreement. On a typical target at 10,000 meters altitude, the maximum 'error' of 8 meters (26 feet) occurs when the target is at a range of 211 nautical miles and the elevation angle is 0 degrees. By the time the target range has decreased to 178 nautical miles (0.5 degree elevation angle), the 'error' in determining the target altitude is only 2 meters (6.5 feet), and by a range of 62 miles, it has dropped to less then 1 meter (3.28 feet). The 'errors' in the spherical slab solution for the same target positions are 607 meters (1991 feet), 238 meters (781 feet), and 9 meters (29.5 feet), and the 'error' in the Cyber results (given only for the last point) is 17 meters (55 feet). By the time the target is in to a range of about 28 miles, both the gradient solution and the spherical slab solution show 'errors' of less than 1 meter, while the Cyber solution still has an 'error' of approximately 4.5 meters (15 feet). This indicates that the gradient solution has about 100 times the 'accuracy' of the spherical slab solution at elevation angles below 1 degree, but that the advantage decreases until, at about 10 degrees, the results from the two solutions are almost in agreement. The Cyber solution is invalid for elevation angles below 1 degree, but between 1 and 2 degrees seems to have better accuracy than the spherical slab solution. Above 2 degrees the spherical slab solution seems to have a slight advantage over the Cyber method.

Thus, it can be concluded that, for very low-elevation angle tracking requirements, only the gradient solution yields reasonably valid results. From the appearances of the plot for a target at 10,000 meters (32,808 feet), both the Cyber and spherical slab solutions must be considered to be invalid below about 2 degrees elevation angle.

One additional comment should to be made regarding the 'errors' based on the JSC 'exact' solution. The JSC solution used 500 iterations for elevation angles of 3 degrees and above, 5000 iterations for elevation angles of 0.5 to 2.5 degrees, and 50,000 iterations for 0 degrees elevation angle. Note that on the 10,000 meter plot, the gradient refraction difference plot has a noticeable but small jump from 3.0 to 2.5 degrees and a significant jump from 0.5 to 0 degrees. Since there was no change in the computational method used in the gradient solution at these points, the jumps can only be attributed to changes in the JSC results which occurred at 0 degrees and in the range from 0.5 to 2.5 degrees where the

jumps are noted. Therefore, it is entirely possible that, in spite of the large word length used in the JSC solution, roundoff error may nevertheless have caused inaccuracy in very low elevation values shown in the JSC tables.

5.0 Phase II - COMPARISONS USING EDWARDS ATMOSPHERES

For this phase of the propagation path modeling, five Edwards atmospheres were used to determine the effects of non-exponential refractivity lapse rates on refraction corrections from the spherical slab and Cyber methods.

In the Phase I analysis, all of the solution methods used surface refractivity values in order to determine the amount of correction to be applied to the measured target position values. With both the spherical slab solution and the Cyber solution, the exponential lapse rates are inherent in the solution methods. In the gradient solution, the refractivity values for 1000-foot altitude intervals were computed from the surface values using the exponental decay factor given in the JSC tables. For interim altitudes, an exponential interpolation was used.

In the phase II analysis, the psychrometric data profiles for each of the test atmospheres were used to compute the true refractivity for even 1000 foot altitude points required by the gradient refraction solution, and exponential extrapolations were used for the interim altitudes. Again the altitude comparisons were made for the altitude range from 1000 meters (3281 feet) up to 100,000 meters (328,084 feet).

For this part of the analysis, the gradient refraction solution served as the 'exact' method. In order to arrive at the input values of measured range and elevation, a ray was propagated from the source starting at the selected elevation angle. The iteration was continued until arriving at the segment where the desired altitude was contained within the iteration cell. At this point, the final incremental range and angle changes were obtained by interpolation. The measured range was determined by the sum total of the refraction adjusted incremental range measurements. Measured range values for each increment were obtained from the relation

$$Rm_i = R_i/n_i,$$

where Rm_i is the incremental segment of measured range, R_i is the true incremental range, and n_i is the index of refraction derived for the cell from the selected atmospheric profile. This value of Rm, along with the starting value of Em, served as the input parameters for the other two refraction correction methods analyzed.

The tabulated results from the Phase II analysis are provided in appendices D through H. As in the Phase I analysis, each table contains values for targets at altitudes of 1000, 2000,

5000, 10,000, 20,000, 50,000, and 100,000 meters. The results in appendix D were computed for the atmospheric conditions given for the EHA-75 atmosphere, and appendix E provides results for the ECA-75 atmosphere. Appendices F through H provide results for a typical cold moist morning, a warm moist morning, and a hot day afternoon.

In all of these tables, the heading data gives the name of the test profile being analyzed, the computed sea level refractivity, and the scale height used by the spherical slab solution. The input data are the elevation angle and range determined from the gradient solution. The next columns provide the corrected elevation and range for the gradient and spherical slab solutions and the corrected elevation for the Cyber solution.

In the altitude section of the listing, the first column shows the geometric altitude which would be obtained without any refraction correction, the second column shows the values obtained with the gradient solution serving as the 'exact' method, and the third and fourth columns show the altitudes determined from the Cyber and spherical slab solutions respectively. A row of asterisks in the Cyber columns indicate that the refractivity value is outside the range of values in the Cyber program.

5.1 Edwards EHA-75 Hot Day

Psychrometric data for the EHA-75 atmosphere are provided on pages D-2 and D-3.

Plots of the results of altitude calculations from the three solution methods for the psychrometric parameters associated with the EHA-75 atmosphere are provided in figures 5-1(a) to 5-1(d) which represent altitudes of 2000, 5000, 10,000, and 50,000 meters (6562, 16,404, 32,808, and 164,042 feet).

For the 2000-meter (6562-foot) altitude, the spherical slab results, shown by the short dash, come into agreement with the gradient solution at about 3 degrees elevation angle. The Cyber solution comes into good agreement by about 2 degrees. Although both the Varian and Cyber solutions have significant errors at the very low elevation angles, it appears that the Varian solution is more erratic at the lower elevation angles.

On the 5000-meter (16,404-foot) plot, both the spherical slab and Cyber solutions come essentially into agreement with the gradient solution by about 8 degrees elevation angle. Results from both solutions have less than 10 meters (32.8 feet) of 'error' from about 2 degrees upward and less than 4 meters (13.1 feet) of 'error' from about 5 degrees upward. The Cyber solution does have a residual error of about one meter (3.28 feet) at the higher angles. This is because no range correction is made.

The 10,000-meter (32,808-foot) altitude plot shows acceptable agreement above about 10 degrees elevation angle. At 5 degrees elevation, both the Cyber and the Varian method have 'errors' of about 20 meters (65.6 feet). At 10 degrees elevation angle, the 'error' in the Varian solution is about 2.5 meters (8.2 feet) and the 'error' in the Cyber solution is about 7 meters (23.0 feet). Again the larger error in the Cyber solution can be attributed to the fact that no range corrections are made.

The 50,000-meter (164,042-foot) altitude plot shows good agreement between the gradient and Cyber methods for elevation angles above about 20 degrees. The 'error' in both the Cyber and Varian methods is about 160 meters (525.0 feet) at 5 degrees elevation angle. Both solutions converge toward the gradient results as the elevation angles increase. In this case, the lack of range correction in the Cyber method causes a bias of about 10 meters (32.8 feet) in high-angle solutions.

Again, the Cyber algorithms provided a smoother plot at the lower elevation angles where the Varian solution was erratic.

Table I provides a comparison of the 'errors' in the Cyber and Varian solutions. The first columns, labelled 'EXP,' show the errors inherent in the solution methods, even if the atmosphere were truly exponential in nature. The second columns, labelled 'EHA,' show the 'error' in results from the the two solution methods when the atmosphere follows the EHA-75 composition. For this comparison, the exponential atmosphere having the 0.0003307 sea level refractivity value was used. Note that for targets at normal tracking altitudes of 10,000 meters (32,808 feet) and below and at elevation angles above 10 degrees, the errors are relatively small. For higher altitude targets or lower elevation angles, the errors due to the atmospheric variations can significantly increase the errors inherent in the solution method.

More complete comparisons can be made using the tabulated data contained in appendix D.

TABLE I - COMPARISON OF ERRORS (EHA-75)

Altitude, meters	El angle, degrees	Cyber error, meters alt.		Varian error, meters alt.	
		EXP	EHA	EXP	EHA
2,000	2	-1	0	+2	+2
	5	0	0	0	0
	10	0	0	0	0
5,000	2	+2	+10	+9	+13
	5	+3	+4	+3	+4
	10	+2	+2	0	0
10,000	2	+11	+44	+39	+70
	5	+12	+20	+13	+19
	10	+2	+5	0	+1
50,000	2	-310	+25	+28	+404
	5	+41	+159	+58	+171
	10	+27	+66	+4	+43
	20	+10	+19	0	+10

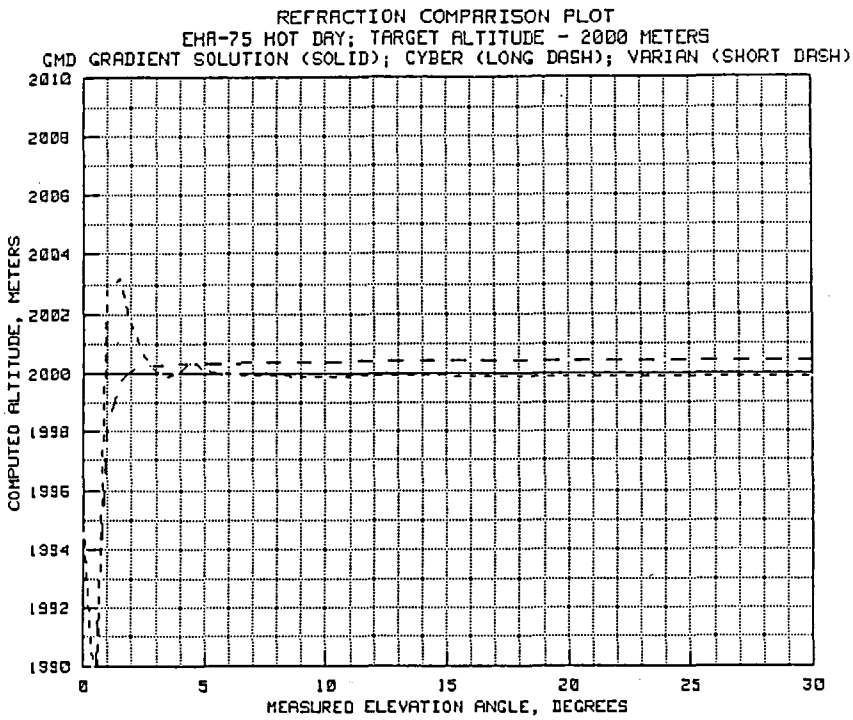

Figure 5-1(a). Plots for target at 2000 meters altitude.

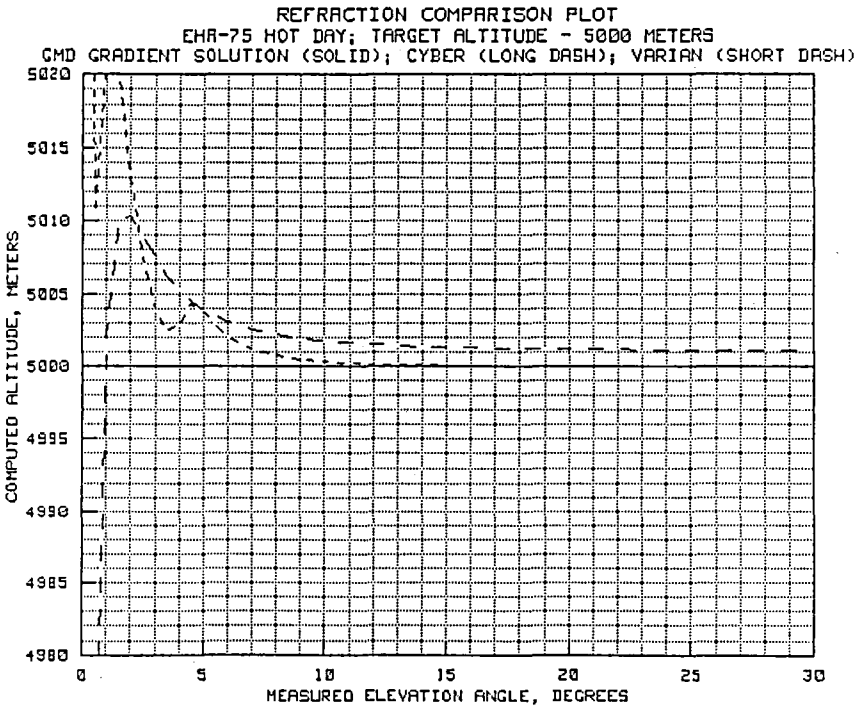

Figure 5-1(b). Plots for target at 5000 meters altitude.

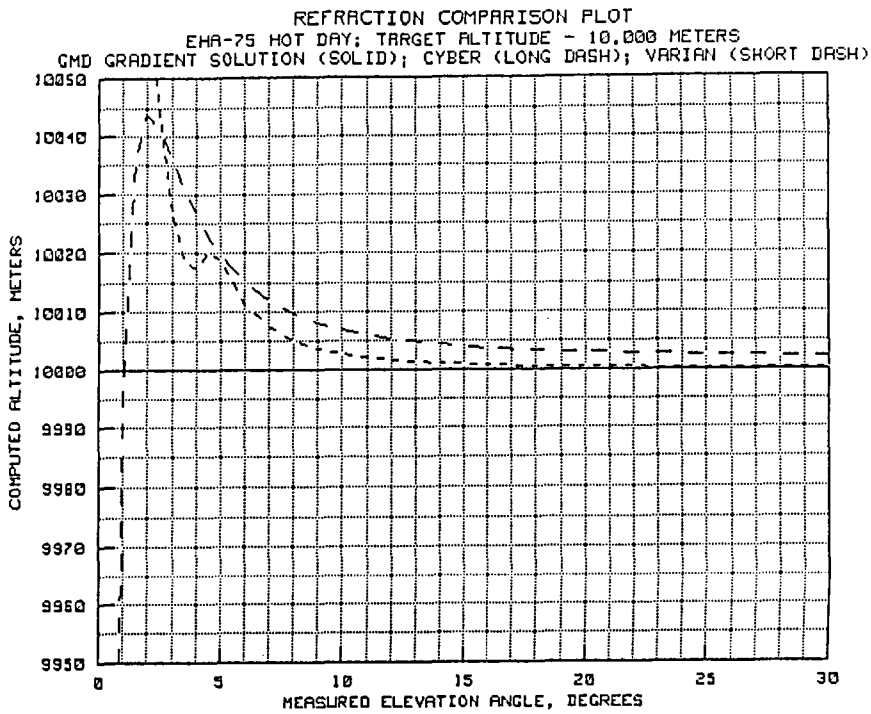

Figure 5-1(c). Plots for target at 10,000 meters altitude.

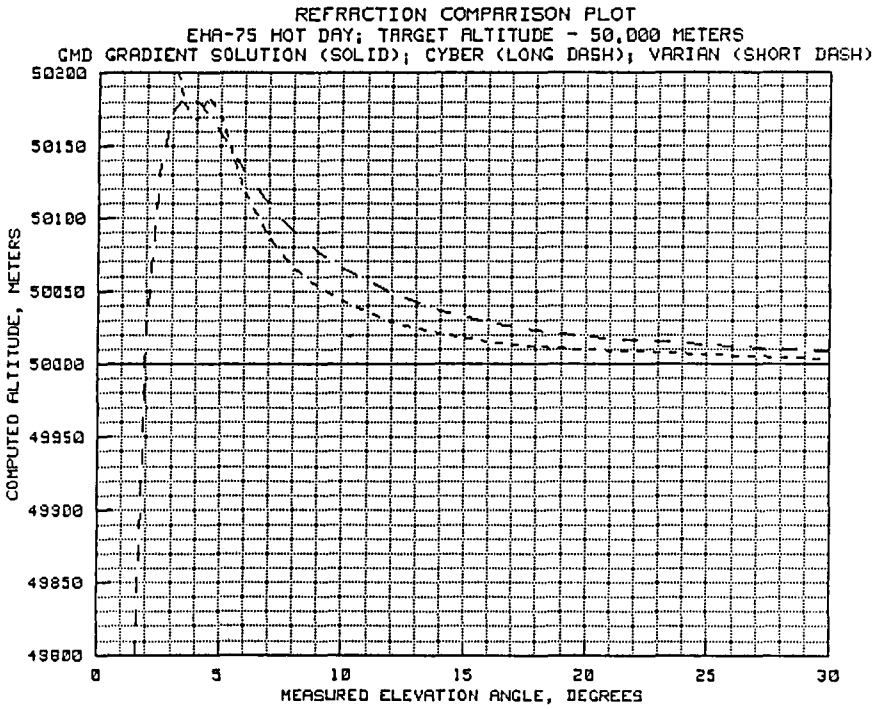

Figure 5-1(d). Plots for target at 50,000 meters altitude.

5.2 Edwards ECA-75 Cold Day

Psychrometric data for the ECA-75 atmosphere are provided on pages E-2 and E-3.

Plots showing the results of comparisons between the three refraction correction methods are provided in figures 5-2(a) to 5-2(d).

The 2000-meter (6562-foot) altitude plot for this atmospheric model shows excellent results from both the Cyber and Varian solutions for all elevation angles above about 2 degrees. However, the results degrade rapidly as the elevation angle decreases below 2 degrees.

The 5000-meter (16,404-foot) plot shows 'errors' in the two solution methods to be under 10 meters (32.8 feet) for all elevation angles above 2.5 degrees, decreasing to under 5 meters (16.4 feet) for all elevation angles above 4 degrees. The error in the Varian solution becomes negligible at elevation angles above 7 degrees. The Cyber solution still shows an error of 3 meters (9.8 feet) at 7 degrees elevation angle. Again, this error is due to the absence of a range correction in the Cyber solution.

The 10,000-meter (32,808-foot) plot shows 'errors' of 21 to 22 meters (68.9 to 72.2 feet) for both the Cyber and Varian solutions at 5 degrees elevation angle. By 10 degrees elevation angle, the Cyber 'error' has dropped to 7 meters (23.0 feet) and the Varian 'error' has dropped to 3 meters (9.8 feet). As the elevation angle increases above about 12 degrees the elevation error in both solution methods is negligible; however, the range bias still remains in the Cyber solution and this results in an error of several meters in the altitude calculations.

The 50,000-meter (164,042-foot) altitude plot is almost identical with the same plot for the EHA-75 atmosphere. At 5 degrees, the 'errors' in the Cyber and Varian solutions are 149 and 166 meters (488.8 and 544.6 feet), respectively. By 10 degrees elevation, the 'errors' in the two solutions have decreased to 63 and 40 meters (206.7 and 131.2 feet), and by 20 degrees elevation they have decreased to 18 and 9 meters (59.1 and 29.5 feet).

Table II shows inherent errors in both solution methods when compared with the results from an exponential atmosphere (0.0003307 Nsl) in the real-world (gradient) solution and with the ECA-75 parameters in the real-world solution. Again the exponential 'errors' are found in the column labelled 'EXP,' and the ECA-75 'errors' are found in the column labelled 'ECA.'

TABLE II - COMPARISON OF ERRORS (ECA-75)

Altitude, meters	El angle, degrees	Cyber error, meters alt.		Varian error, meters alt.	
		EXP	ECA	EXP	ECA
2,000	2	-1	-1	+2	+2
	5	0	0	0	0
	10	0	0	0	0
5,000	2	+2	+9	+9	+16
	5	+3	+4	+3	+4
	10	+2	+2	0	0
10,000	2	+11	+45	+39	+76
	5	+12	+21	+13	+22
	10	+2	+7	0	+3
50,000	2	-310	-23	+28	+342
	5	+41	+149	+58	+166
	10	+27	+63	+4	+40
	20	+10	+18	0	+9

Tabulated data for this test condition are provided in appendix E.

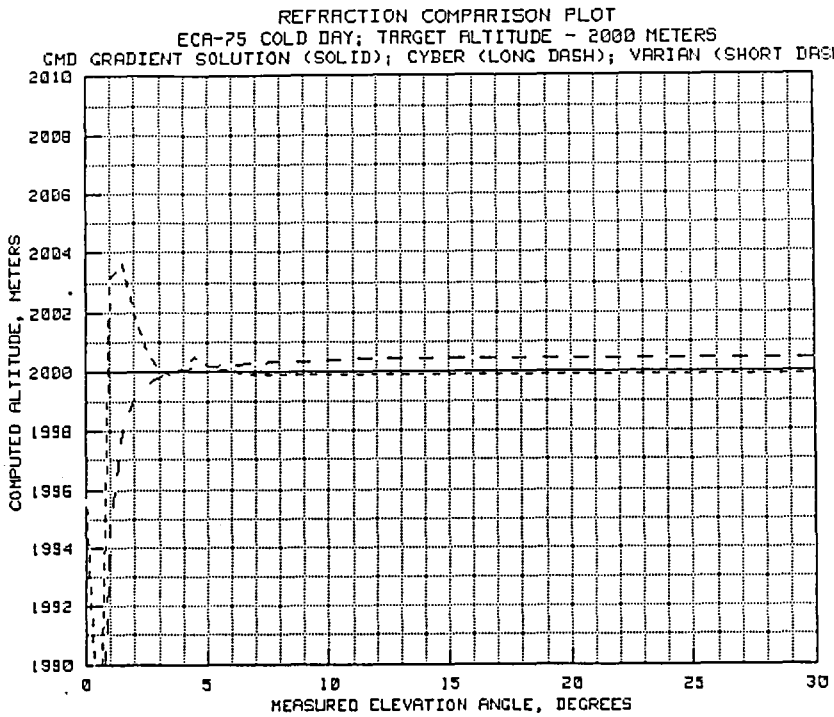

Figure 5-2(a). Plots for target at 2000 meters altitude.

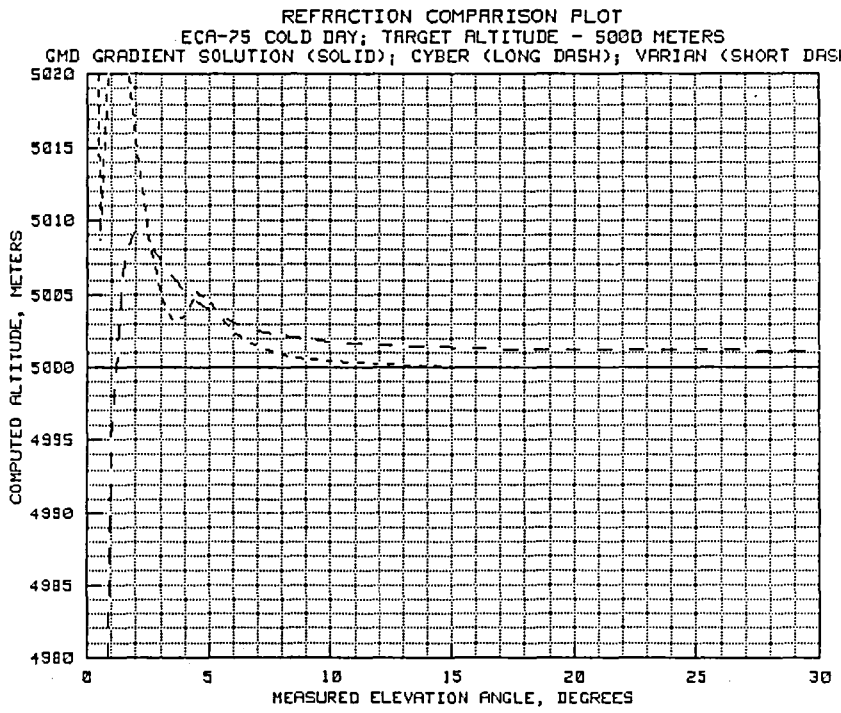

Figure 5-2(b). Plots for target at 5000 meters altitude.

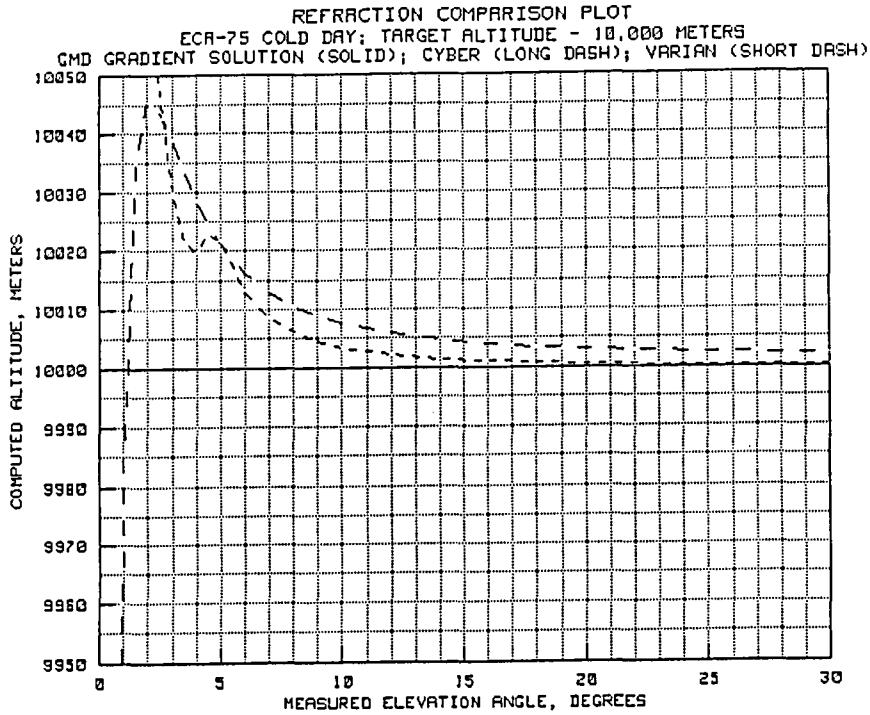

Figure 5-2(c). Plots for target at 10,000 meters altitude.

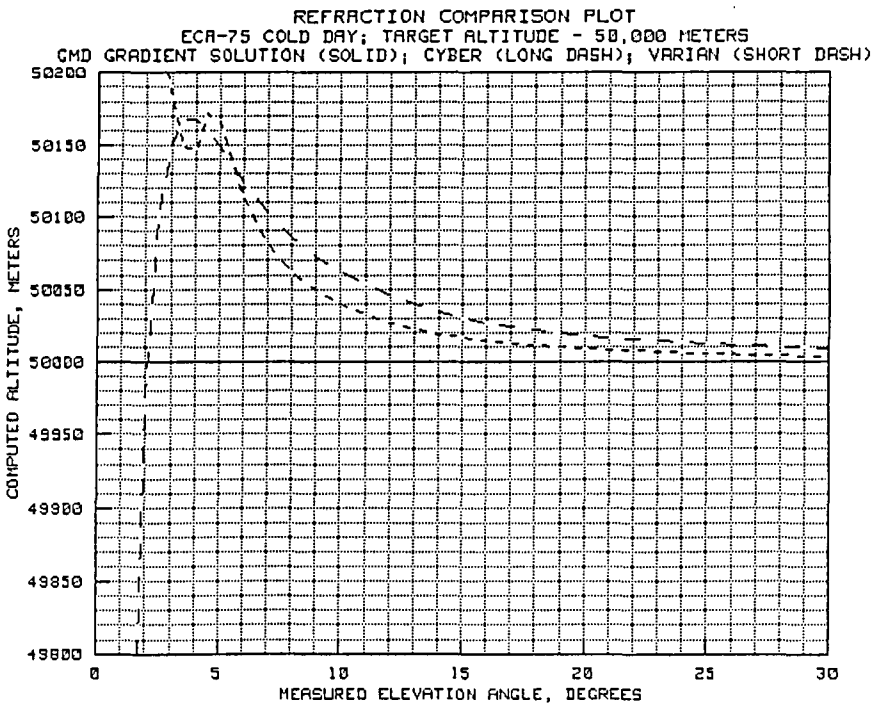

Figure 5-2(d). Plots for target at 50,000 meters altitude.

5.3 Edwards Cold Moist Morning

The psychrometric data for the cold moist morning atmospheric model are provided on pages F-2 and F-3.

Results for each solution method for altitudes of 2000 meters (6562 feet), 5000 meters (16,404 feet), 10,000 meters (32,808 feet), and 50,000 meters (164,042 feet) are provided in figures 5-3(a) to 5-3(d), respectively.

Results from the 2000-meter (6562-foot) altitude plot indicate that both the Cyber and the Varian solutions yield excellent results for all elevation angles above about 2 degrees. Results from both solutions below 2 degrees elevation angle are unusable.

Data from the 5000-meter (16,404-foot) altitude plot show good agreement above 2.5 degrees elevation angle for both methods. Below 2.5 degrees the results are unusable.

The 10,000-meter (32,808-foot) altitude plot shows that the Varian results become useable above about 8 degrees ('error' less than 4 meters (13.1 feet). Cyber results become useable at about 15 degrees. Below 2.5 degrees elevation angle, both solution methods fail. At 2.5 degrees elevation angle, the 'errors' in both solutions are about 30 meters (98.4 feet).

The 50,000-meter (164,042-foot) altitude plot again shows about the same behavior as the 50,000-meter plots for the previous test conditions. Significant 'errors' are present for all elevation angles above about 15 degrees.

In all cases, the lack of range refraction correction in the Cyber solution causes unnecessary inaccuracies in the results, even at the higher elevation angles where the elevation correction is accurate.

Table III provides a comparisons of 'errors' in the two solution methods based on gradient results with (1) an exponential atmosphere and (2) the cold moist morning atmosphere. The 'errors' between the results of the two solutions and the exponential (Nsl=0.0003307) case are in the column labelled 'EXP.' The 'errors' between the results of the two solutions and the cold-moist-morning case are found in the columns labelled 'CMST.' More detailed analyses can be made using the tabulated data in appendix F.

TABLE III - COMPARISON OF ERRORS (COLD MOIST MORNING)

Altitude, meters	El angle, degrees	Cyber error, meters alt.		Varian error, meters alt.	
		EXP	CMST	EXP	CMST
2,000	2	-1	-2	+2	+1
	5	0	0	0	0
	10	0	0	0	0
5,000	2	+2	+1	+9	+8
	5	+3	+2	+3	+3
	10	+2	+1	0	0
10,000	2	+11	+25	+39	+55
	5	+12	+17	+13	+17
	10	+2	+6	0	+2
50,000	2	-310	-102	+28	+253
	5	+41	+128	+58	+146
	10	+27	+57	+4	+34
	20	+10	+16	0	+7

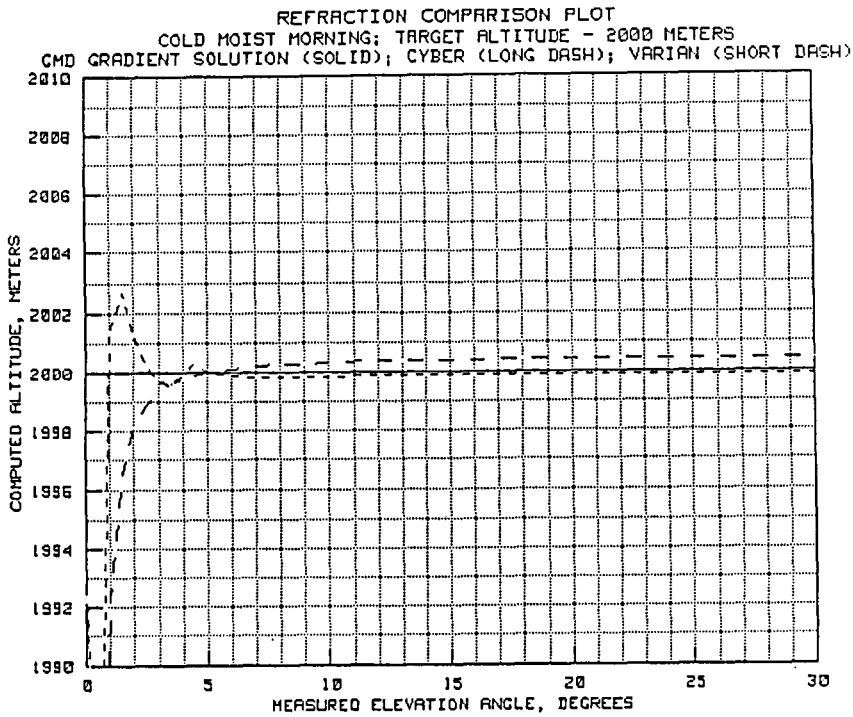

Figure 5-3(a). Plots for target at 2000 meters altitude.

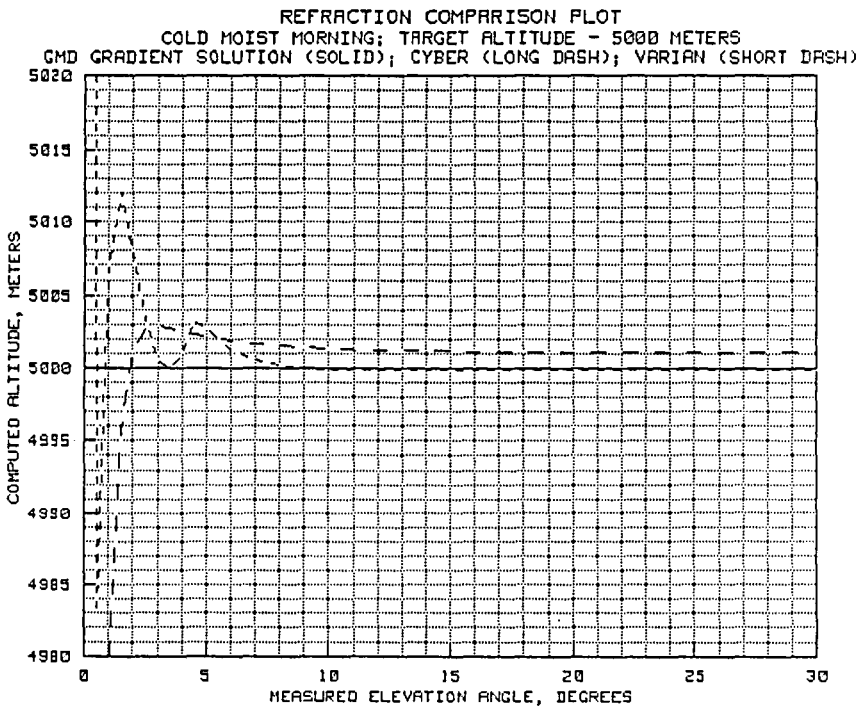

Figure 5-3(b). Plots for target at 5000 meters altitude.

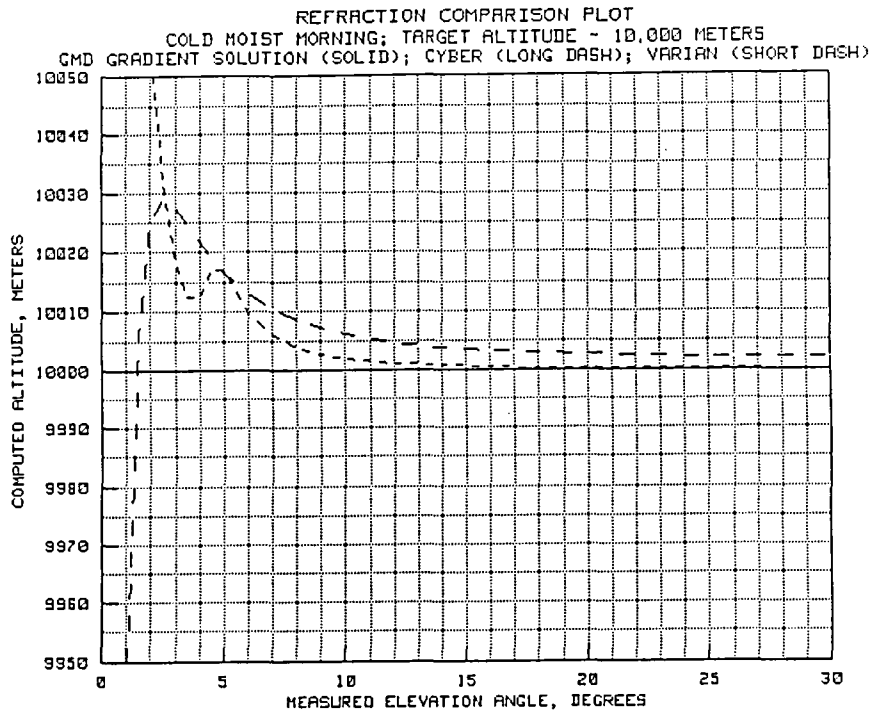

Figure 5-3(c). Plots for target at 10,000 meters altitude.

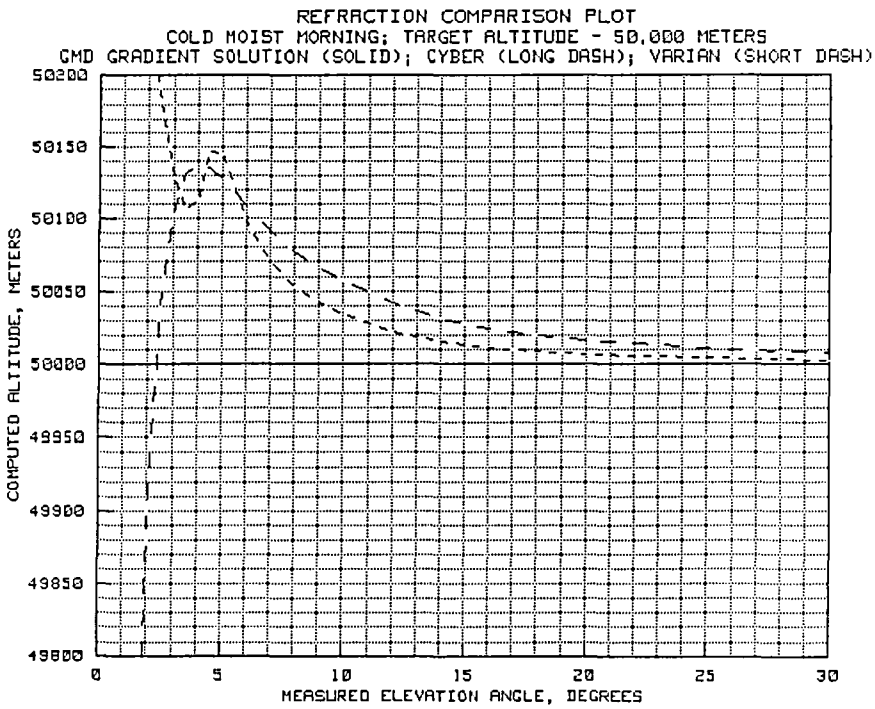

Figure 5-3(d). Plots for target at 50,000 meters altitude.

5.4 Edwards Warm Moist Morning

The psychrometric data for the warm moist morning atmospheric model are provided in table G-I (pp. G-2 and G-3).

Results for each solution method for altitudes of 2000 meters (6562 feet), 5000 meters (16,404 feet), 10,000 meters (32,808 feet), and 50,000 meters (164,042 feet) are provided in figures 5-4(a) to 5-4(d). Note that, the surface refractivity values for this test case fall outside the table limits for the Cyber solution, therefore only the gradient and spherical slab results are shown in the plots.

Results from the 2000-meter (6562-foot) altitude plot indicate that the spherical slab solution comes into fair agreement with the gradient results at angles above about 2 degrees, and essentially converges at elevation angles above about 4 degrees.

Data from the 5000-meter (16,404-foot) altitude plot show useable data from the spherical slab solution at angles above about 4.5 degrees, and essentially identical results with the gradient solution at angles above 10 degrees.

The 10,000-meter (32,808-foot) altitude plot shows that the spherical slab results are useable above about 4.5 degrees and provide good agreement with the 'exact' solution above 5 degrees.

The 50,000-meter (164,042-foot) altitude plot shows sizeable errors in the spherical slab results until above about 15 degrees elevation angle. From about 2.5 to 15 degrees the 'error' ranges up to about 145 meters (475.7 feet).

Table IV provides a comparison of the 'errors' from the use of the Edwards warm moist morning with those present when the assumption is made that the real-world atmosphere is exponential. No Cyber data were available for this comparison.

TABLE IV - COMPARISON OF ERRORS (WARM MOIST MORNING)

Altitude, meters	El angle, degrees	Cyber error, meters alt.		Varian error, meters alt.	
		EXP	WMST	EXP	WMST
2,000	2	-1	****	+2	-3
	5	0	****	0	-1
	10	0	****	0	0
5,000	2	+2	****	+9	-26
	5	+3	****	+3	-4
	10	+2	****	0	-2
10,000	2	+11	****	+39	-35
	5	+12	****	+13	-1
	10	+2	****	0	-3
50,000	2	-310	****	+28	-28
	5	+41	****	+58	+145
	10	+27	****	+4	+39
	20	+10	****	0	+9

Tabulated data for this test condition are provided in appendix G.

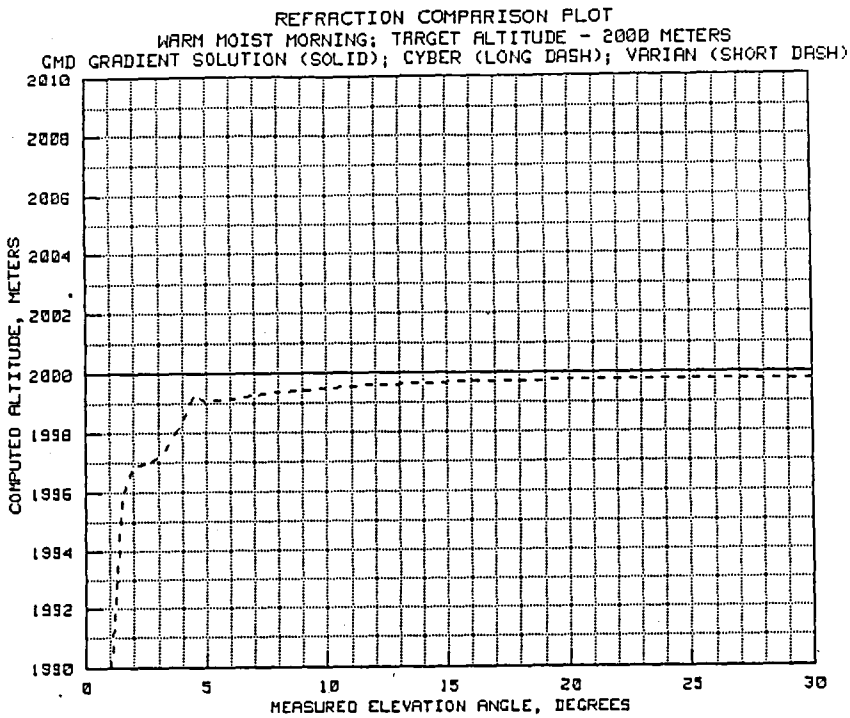

Figure 5-4(a). Plots for target at 2000 meters altitude.

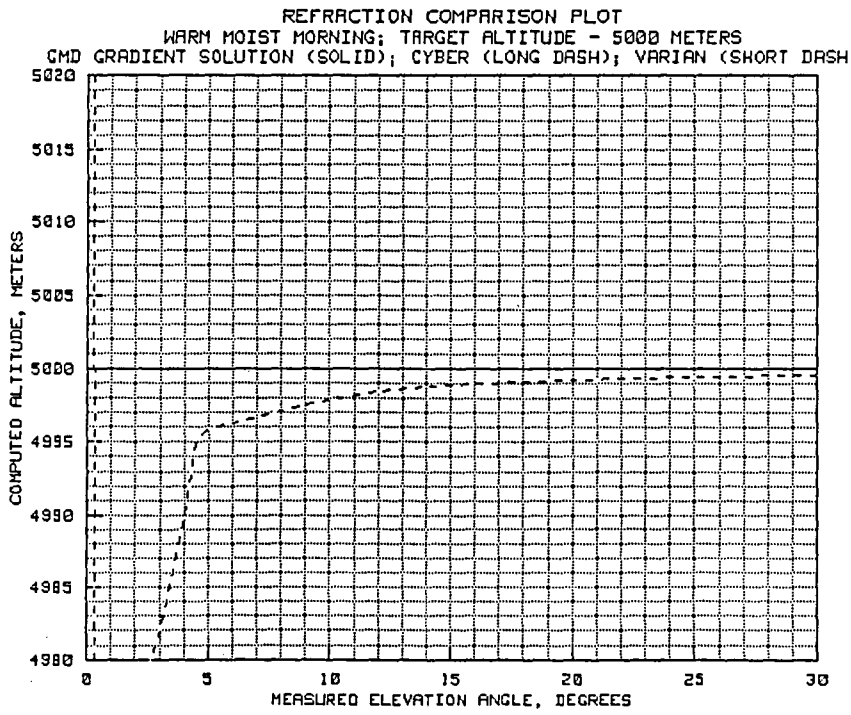

Figure 5-4(b). Plots for target at 5000 meters altitude.

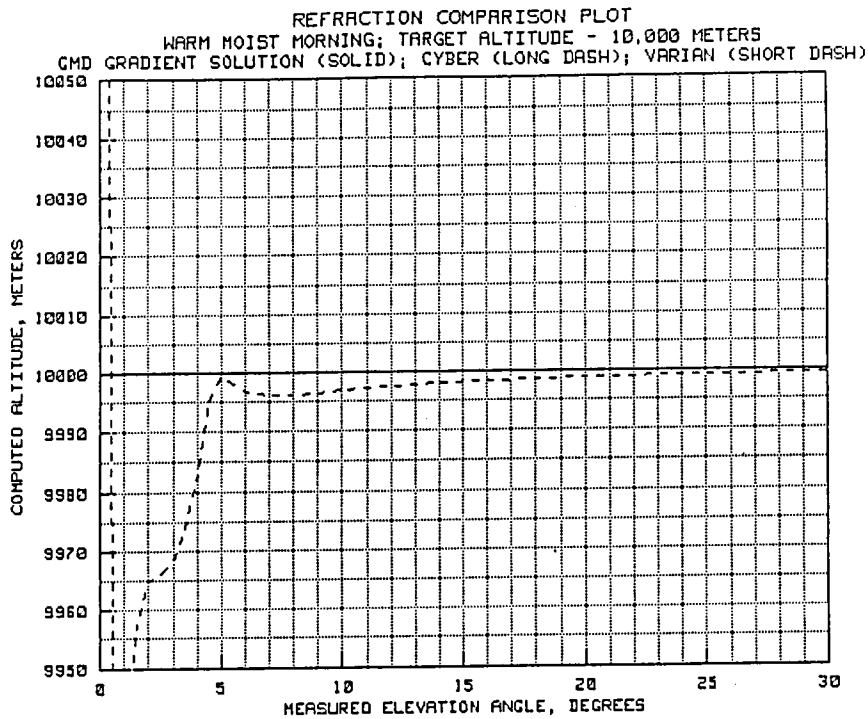

Figure 5-4(c). Plots for target at 10,000 meters altitude.

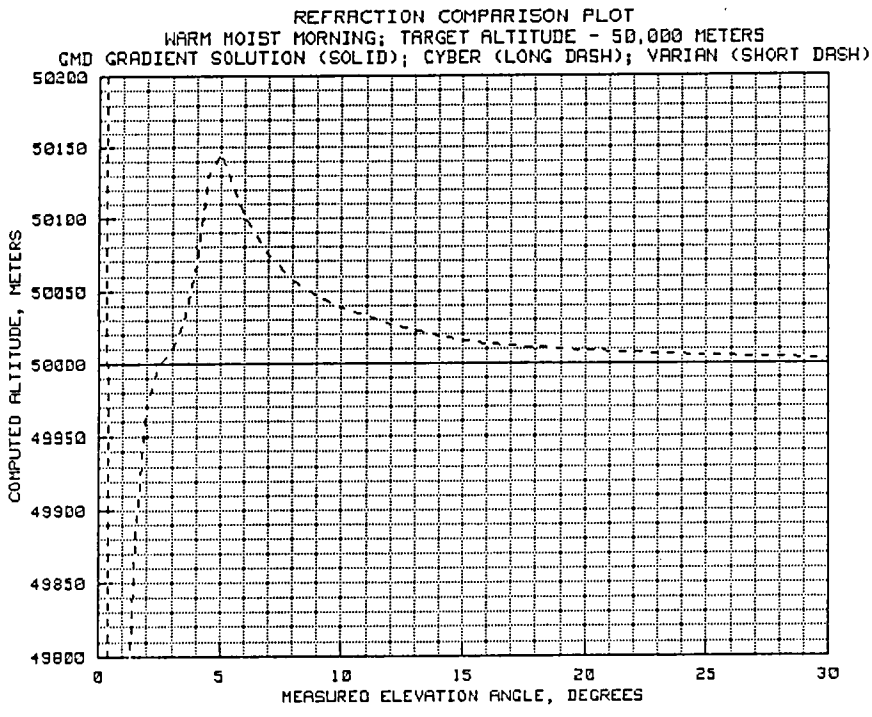

Figure 5-4(d). Plots for target at 50,000 meters altitude.

5.5 Edwards Warm Day Afternoon

The psychrometric data for the warm day afternoon atmospheric model are provided in table H-I, pages H-2 and H-3.

Results for each solution method for altitudes of 2000 meters (6562 feet), 5000 meters (16,404 feet), 10,000 meters (32,808 feet), and 50,000 meters (164,042 feet) are provided in figures 5-5(a) to 5-5(d) respectively.

Results from the 2000-meter (6562-foot) altitude plot indicate that the results of both the Cyber and Varian solutions are valid above about 1.5 degrees. The results are invalid below that point.

Data from the 5000-meter (16,404-foot) altitude plot show valid results with errors of 9 meters (29.5 feet) or below for elevation angles above 2 degrees. By 10 degrees, the Varian solution matches the gradient solution. At the same elevation angle, the Cyber method computes the correct elevation angle, however the inherent range bias causes a small error to remain in the altitude calculations.

The 10,000-meter (32,808-foot) altitude plot shows that both the Cyber and Varian solutions have sizeable errors remaining for elevation angles of 5 degrees. By 10 or 12 degrees, the Varian solution obtains good agreement with the gradient method, but the Cyber solution still has an error of about 5 meters due to the lack of range correction.

The 50,000-meter (164,042-foot) altitude plot again shows agreement in the results from the Cyber and Varian solutions above 5 degrees, but both have 'errors' of about 170 meters (557.7 feet) at that point. By 10 degrees elevation angle, errors from about 45 to 70 meters (147.6 to 229.7 feet) are still present. At about 21 degrees elevation angle, the 'errors' in the Varian solution finally go below 10 meters (32.8 feet). The 'errors' in the Cyber solution are almost double those in the Varian solution at the same point because of the range bias.

Table V provides a comparison of the 'errors' when using atmospheric data from the Edwards warm day afternoon with those present when using the exponential real-world atmosphere. Again, the inherent use of an exponential atmosphere by both the Cyber and Varian refraction correction methods only causes minor errors for angles above 5 degrees for target altitudes at or below 10,000 meters (32808 feet). However, for the 50,000-meter target, the assumption of an exponential lapse rate can cause sizeable errors.

TABLE V - COMPARISON OF ERRORS (WARM DAY AFTERNOON)

Altitude, meters	El angle, degrees	Cyber error, meters alt.		Varian error, meters alt.	
		EXP	WMAFT	EXP	WMAFT
2,000	2	-1	0	+2	+1
	5	0	0	0	0
	10	0	0	0	0
5,000	2	+2	+9	+9	+10
	5	+3	+4	+3	+3
	10	+2	+2	0	0
10,000	2	+11	+43	+39	+66
	5	+12	+19	+13	+18
	10	+2	+7	0	+3
50,000	2	-310	+57	+28	+433
	5	+41	+169	+58	+178
	10	+27	+69	+4	+46
	20	+10	+20	0	+10

Tabulated data for this test condition are provided in appendix H.

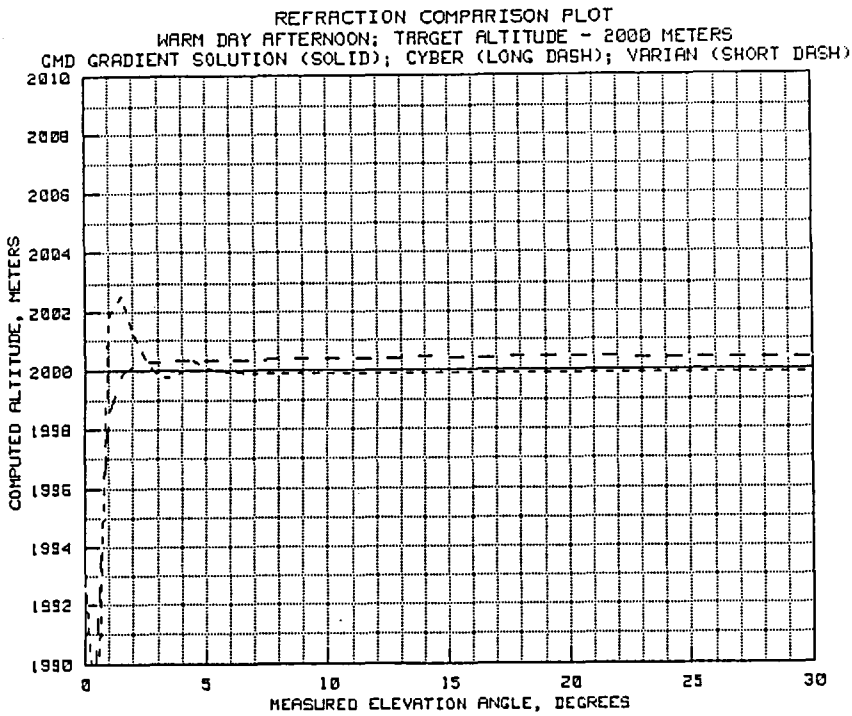

Figure 5-5(a). Plots for target at 2000 meters altitude.

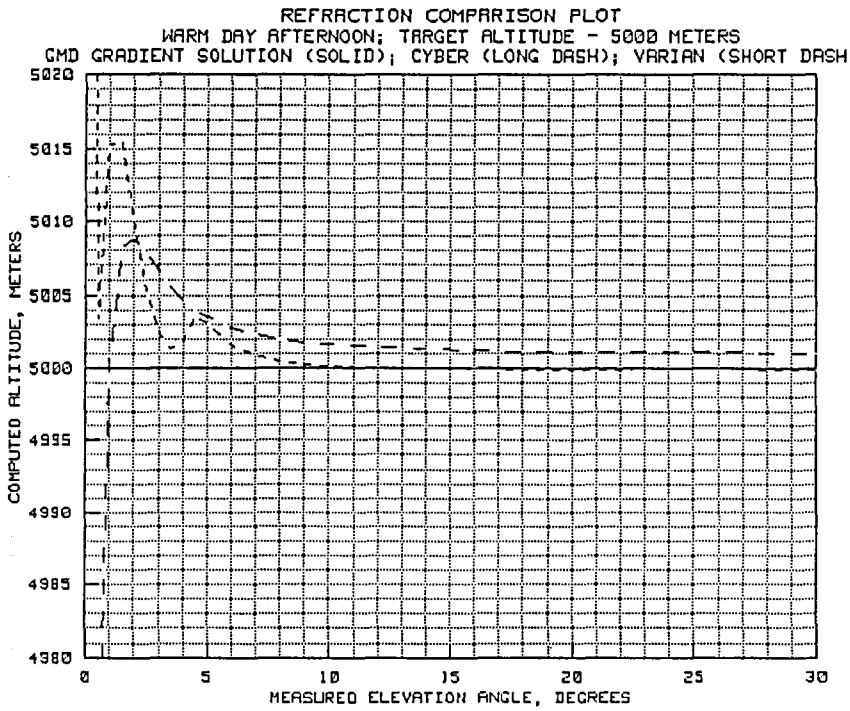

Figure 5-5(b). Plots for target at 5000 meters altitude.

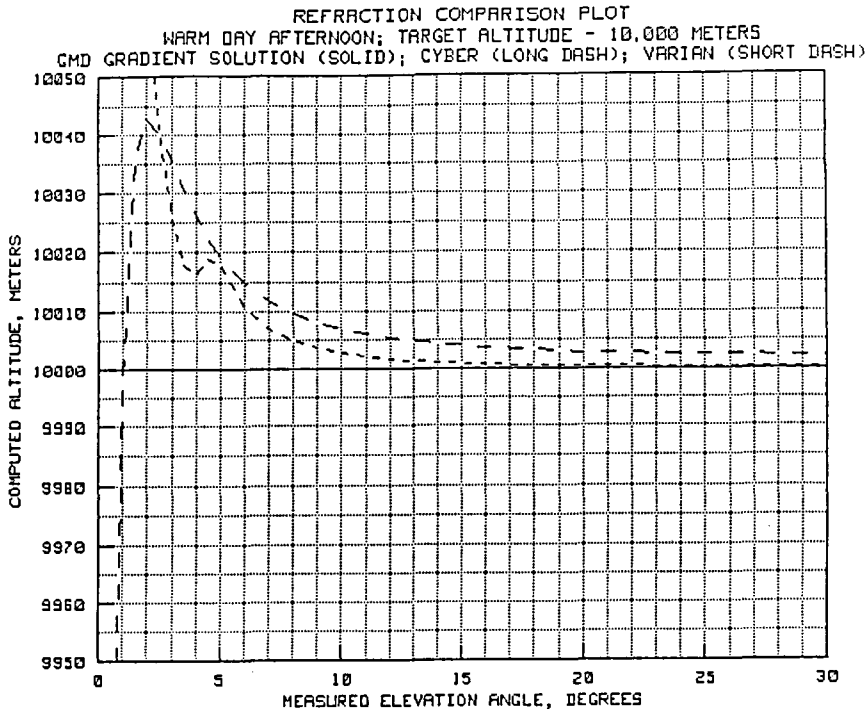

Figure 5-5(c). Plots for target at 10,000 meters altitude.

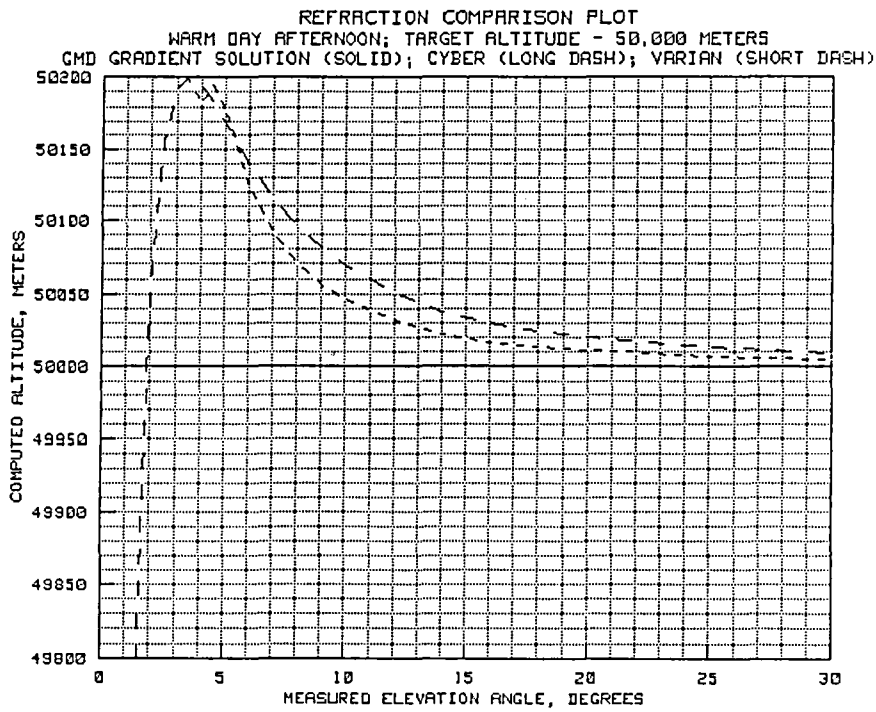

Figure 5-5(d). Plots for target at 50,000 meters altitude.

5.6 Results of the Phase II Analysis

The phase II analysis provides a good comparison of the results of the three solution methods when non-exponential atmospheric conditions exist. Both the Cyber and Varian solutions appear to 'hold' down to the same elevation angles for targets at all altitudes. However, the Cyber solution has a slightly greater error noticeable at the higher elevation angles simply because there is no correction for the effects of refraction on the range measurements. If the Cyber solution is to be used in the future, then the simple range correction provided in reference 10 should also be incorporated.

In both the phase I analysis and the phase II analysis, it was found possible to exceed the range of values in the Cyber refraction tables. This is shown as asterisks on the tabulated plots in the appendices. If this were to happen during an actual reduction of data on the Cyber, then an error message would print out advising the operator that the table values had been exceeded. Although the Cyber tables could easily be expanded to cover a wider range of atmospheric conditions and altitudes, it nevertheless should be noted that the Cyber method was devised to support missile testing at White Sands and was, according to information contained in reference 10, only intended for use at ranges from 500 to 200,000 yards (about 100 nautical miles). In this analysis, the Cyber routines did fail when the ranges were very long and the elevation angles very low, indicating that the published range limitations are reasonably correct for normal tracking missions. However, it was also found that the Varian (spherical slab) solution had approximately the same limits and yielded highly erratic results when the elevation values fell below those limits.

With the addition of a range correction and with some expansion of the Cyber tables, the Cyber refraction correction method could be acceptable for normal aircraft tracking missions so long as the elevation angles were above values at which error limits for the specific mission were not exceeded. These can be easily determined from the tabulated data for the atmospheric conditions which most closely match the flight day conditions. In fact, if a range correction were incorporated, the Cyber solution would provide more consistent data as the elevation angle approached the failure point. Useable results, often with sizeable errors, can be obtained from both solutions down to the failure points. Below the failure points, the results are totally unusable.

Failure points for both methods are approximately 1.5 degrees elevation angle for a target at 2000 meters (6,562 feet),

2 to 2.5 degrees for a target at 5000 meters (16,404 feet), 2.5 to 3.5 degrees for a target at 10,000 meters, and about 4 degrees for a target at 50,000 meters. Data obtained at elevation angles below the failure points will have extremely large errors, and data obtained just slightly above the failure points can still have sizeable bias errors.

Both the Cyber and Varian refraction correction methods assume an exponential lapse rate for the modulus of refraction. This does cause some increase in the 'errors' in the results, mostly at the lower elevation angles. Again, it must be an operational decision as to how much error is 'allowable' for any specific mission. By noting the amount of 'error' shown in the tabulated results for atmospheric conditions most closely matching those of the test day, decisions can be made as to the lowest useable elevation angles for tracks at specific altitudes.

For orbital tracks, if extremely large errors are to be avoided, one of the 'exact' methods must be used. After each Shuttle mission, data from all participating radars in the world-wide NASA/DoD tracking network are analyzed. Bias errors of 30 to 40 meters are considered excessive. Since many of the orbital tracks are performed at fairly low elevation angles, neither the Cyber nor the Varian methods would provide corrections suitable for post-mission analysis.

6.0 REFERENCES

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APPENDIX A

TABULATED REFRACTION COMPARISON DATA FOR SEA-LEVEL MODULUS OF REFRACTION OF 0.0002550

COMPARISON OF GRADIENT (GMD), WHITE SANDS (CYBER) AND SPHERICAL SLAB (VARIAN) CORRECTION METHODS

BASED ON MEASURED VALUES CONTAINED IN JSC INTERNAL NOTE 75-FM-60 'REFRACTION CORRECTIONS FOR AN EXPONENTIAL ATMOSPHERE'

SEA LEVEL MODULUS OF REFRACTION: .0002550 SCALE HEIGHT: 7891.85 TARGET ALTITUDE: 1000 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	126366.26	-.1139	126335.27	-.1131	-.1158	126328.15	1252	1000	1002	996
.5	74598.29	.4339	74580.28	.4358	.4315	74579.37	1087	1001	1004	998
1.0	48756.97	.9572	48745.25	.9585	.9574	48745.04	1037	1001	1002	1001
1.5	35232.32	1.4693	35223.87	1.4702	1.4698	35223.83	1020	1000	1001	1001
2.0	27318.02	1.9763	27311.47	1.9769	1.9765	27311.48	1012	1000	1001	1000
2.5	22220.80	2.4809	22215.48	2.4812	2.4806	22215.49	1008	1000	1001	1000
3.0	18693.10	2.9840	18688.62	2.9842	2.9835	18688.64	1006	1000	1000	1000
3.5	16117.68	3.4863	16113.82	3.4864	3.4857	16113.83	1004	1000	1000	1000
4.0	14159.13	3.9881	14155.74	3.9881	3.9877	14155.75	1003	1000	1000	1000
4.5	12621.62	4.4894	12618.60	4.4894	4.4894	12618.60	1003	1000	1000	1000
5.0	11383.65	4.9905	11380.92	4.9904	4.9901	11380.93	1002	1000	1000	1000
6.0	9515.18	5.9922	9512.90	5.9920	5.9917	9512.90	1002	1000	1000	1000
7.0	8173.50	6.9934	8171.54	6.9932	6.9929	8171.54	1001	1000	1000	1000
8.0	7164.27	7.9943	7162.55	7.9940	7.9937	7162.55	1001	1000	1000	1000
9.0	6378.03	8.9950	6376.50	8.9947	8.9944	6376.50	1001	1000	1000	1000
10.0	5748.54	9.9955	5747.16	9.9952	9.9950	5747.16	1001	1000	1000	1000
12.0	4804.21	11.9964	4803.06	11.9960	11.9958	4803.06	1001	1000	1000	1000
14.0	4130.38	13.9970	4129.39	13.9966	13.9964	4129.39	1000	1000	1000	1000
16.0	3626.05	15.9975	3625.18	15.9971	15.9969	3625.18	1000	1000	1000	1000
18.0	3234.92	17.9978	3234.15	17.9974	17.9973	3234.15	1000	1000	1000	1000
20.0	2923.12	19.9981	2922.42	19.9977	19.9976	2922.42	1000	1000	1000	1000
25.0	2366.08	24.9986	2365.51	24.9982	24.9981	2365.51	1000	1000	1000	1000
30.0	2000.10	29.9990	1999.62	29.9985	29.9985	1999.62	1000	1000	1000	1000
35.0	1743.64	34.9992	1743.22	34.9988	34.9987	1743.22	1000	1000	1000	1000
40.0	1555.96	39.9994	1555.59	39.9990	39.9989	1555.59	1000	1000	1000	1000
45.0	1414.46	44.9995	1414.12	44.9992	44.9991	1414.12	1000	1000	1000	1000
50.0	1305.66	49.9996	1305.35	49.9993	49.9993	1305.35	1000	1000	1000	1000
60.0	1154.95	59.9998	1154.67	59.9995	59.9995	1154.67	1000	1000	1000	1000
70.0	1064.42	69.9999	1064.17	69.9997	69.9997	1064.17	1000	1000	1000	1000
80.0	1015.67	79.9999	1015.43	79.9999	79.9998	1015.43	1000	1000	1000	1000
90.0	1000.24	90.0000	1000.00	90.0000	90.0000	1000.00	1000	1000	1000	1000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

COMPARISON OF GRADIENT (GMD), WHITE SANDS (CYBER) AND SPHERICAL SLAB (VARIAN) CORRECTION METHODS

BASED ON MEASURED VALUES CONTAINED IN JSC INTERNAL NOTE 75-FM-60 'REFRACTION CORRECTIONS FOR AN EXPONENTIAL ATMOSPHERE'

SEA LEVEL MODULUS OF REFRACTION: .0002550 SCALE HEIGHT: 7891.85 TARGET ALTITUDE: 2000 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	178270.95	-.1578	178228.84	-.1596	-.1602	178223.81	2491	1999	1994	1991
.5	121801.79	.3948	121773.74	.3976	.3900	121772.27	2226	2001	2008	1991
1.0	87098.70	.9256	87078.86	.9287	.9265	87078.41	2114	2001	2006	2002
1.5	65906.59	1.4441	65891.65	1.4467	1.4458	65891.57	2065	2001	2004	2003
2.0	52345.88	1.9558	52334.04	1.9579	1.9569	52334.07	2041	2001	2003	2001
2.5	43157.26	2.4637	43147.51	2.4654	2.4640	43147.57	2028	2000	2002	2001
3.0	36602.46	2.9694	36594.20	2.9707	2.9691	36594.26	2020	2000	2002	2000
3.5	31725.27	3.4735	31718.11	3.4747	3.4731	31718.16	2015	2000	2001	2000
4.0	27969.00	3.9768	27962.69	3.9777	3.9766	27962.73	2012	2000	2001	2000
4.5	24994.22	4.4793	24988.59	4.4801	4.4799	24988.61	2010	2000	2001	2000
5.0	22583.80	4.9814	22578.71	4.9820	4.9814	22578.73	2008	2000	2001	2000
6.0	18922.68	5.9845	18918.42	5.9850	5.9843	18918.42	2006	2000	2001	2000
7.0	16278.67	6.9868	16275.00	6.9871	6.9865	16275.00	2004	2000	2001	2000
8.0	14282.54	7.9885	14279.32	7.9887	7.9881	14279.32	2003	2000	2001	2000
9.0	12723.67	8.9898	12720.80	8.9900	8.9894	12720.80	2003	2000	2001	2000
10.0	11473.44	9.9909	11470.86	9.9910	9.9904	11470.85	2002	2000	2001	2000
12.0	9594.73	11.9925	9592.57	11.9925	11.9920	9592.57	2002	2000	2001	2000
14.0	8252.16	13.9937	8250.30	13.9936	13.9932	8250.30	2001	2000	2001	2000
16.0	7246.36	15.9946	7244.73	15.9944	15.9941	7244.73	2001	2000	2000	2000
18.0	6465.82	17.9953	6464.36	17.9951	17.9948	6464.36	2001	2000	2000	2000
20.0	5843.33	19.9958	5842.01	19.9956	19.9953	5842.01	2001	2000	2000	2000
25.0	4730.71	24.9969	4729.64	24.9966	24.9963	4729.64	2001	2000	2000	2000
30.0	3999.38	29.9975	3998.48	29.9972	29.9970	3998.48	2001	2000	2000	2000
35.0	3486.78	34.9980	3486.00	34.9977	34.9976	3485.99	2001	2000	2000	2000
40.0	3111.59	39.9984	3110.89	39.9981	39.9980	3110.89	2001	2000	2000	2000
45.0	2828.70	44.9987	2828.06	44.9984	44.9983	2828.06	2001	2000	2000	2000
50.0	2611.17	49.9989	2610.58	49.9987	49.9986	2610.58	2000	2000	2000	2000
60.0	2309.82	59.9993	2309.30	59.9991	59.9990	2309.30	2000	2000	2000	2000
70.0	2128.80	69.9996	2128.32	69.9994	69.9994	2128.32	2000	2000	2000	2000
80.0	2031.30	79.9998	2030.84	79.9997	79.9997	2030.84	2000	2000	2000	2000
90.0	2000.45	90.0000	2000.00	90.0000	90.0000	2000.00	2000	2000	2000	2000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

COMPARISON OF GRADIENT (GMD), WHITE SANDS (CYBER) AND SPHERICAL SLAB (VARIAN) CORRECTION METHODS

BASED ON MEASURED VALUES CONTAINED IN JSC INTERNAL NOTE 75-FM-60 'REFRACTION CORRECTIONS FOR AN EXPONENTIAL ATMOSPHERE'

SEA LEVEL MODULUS OF REFRACTION: .0002550 SCALE HEIGHT: 7891.85 TARGET ALTITUDE: 5000 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	280030.55	-.2346	279970.97	-.2507	-.1969	279971.38	6144	4996	4920	5181
.5	219219.81	.3236	219175.28	.3243	.3237	219173.76	5678	5002	5006	5002
1.0	174242.73	.8632	174208.28	.8685	.8663	174207.65	5419	5001	5019	5011
1.5	141525.93	1.3905	141498.38	1.3968	1.3945	141498.29	5273	5001	5018	5011
2.0	117614.62	1.9098	117591.94	1.9159	1.9128	117592.08	5187	5001	5015	5007
2.5	99838.68	2.4239	99819.54	2.4295	2.4254	99819.74	5134	5001	5012	5003
3.0	86324.31	2.9346	86307.82	2.9396	2.9349	86308.02	5100	5001	5009	5001
3.5	75816.91	3.4427	75802.47	3.4472	3.4427	75802.63	5077	5000	5007	5000
4.0	67467.16	3.9492	67454.33	3.9532	3.9497	67454.45	5061	5000	5006	5001
4.5	60702.41	4.4544	60690.88	4.4581	4.4565	60690.97	5050	5000	5005	5003
5.0	55127.38	4.9587	55116.92	4.9620	4.9608	55116.97	5041	5000	5005	5002
6.0	46510.47	5.9653	46501.66	5.9681	5.9664	46501.66	5029	5000	5004	5001
7.0	40185.42	6.9702	40177.81	6.9725	6.9707	40177.80	5022	5000	5003	5001
8.0	35359.66	7.9739	35352.97	7.9759	7.9741	35352.95	5017	5000	5002	5000
9.0	31563.76	8.9768	31557.79	8.9786	8.9768	31557.77	5014	5000	5002	5000
10.0	28503.80	9.9792	28498.41	9.9807	9.9791	28498.39	5011	5000	5002	5000
12.0	23882.29	11.9828	23877.78	11.9840	11.9825	23877.77	5008	5000	5002	5000
14.0	20564.55	13.9853	20560.66	13.9863	13.9850	20560.66	5006	5000	5001	5000
16.0	18071.90	15.9873	18068.49	15.9881	15.9869	18068.48	5005	5000	5001	5000
18.0	16133.78	17.9888	16130.73	17.9895	17.9884	16130.73	5004	5000	5001	5000
20.0	14586.01	19.9901	14583.26	19.9906	19.9897	14583.25	5003	5000	5001	5000
25.0	11815.57	24.9923	11813.34	24.9927	24.9919	11813.34	5002	5000	5001	5000
30.0	9992.13	29.9938	9990.24	29.9941	29.9935	9990.24	5002	5000	5001	5000
35.0	8713.10	34.9950	8711.45	34.9951	34.9946	8711.45	5002	5000	5001	5000
40.0	7776.49	39.9958	7775.02	39.9959	39.9955	7775.02	5001	5000	5001	5000
45.0	7070.10	44.9965	7068.77	44.9966	44.9962	7068.76	5001	5000	5001	5000
50.0	6526.77	49.9971	6525.54	49.9971	49.9968	6525.54	5001	5000	5001	5000
60.0	5773.97	59.9980	5772.88	59.9980	59.9978	5772.88	5001	5000	5001	5000
70.0	5321.66	69.9988	5320.66	69.9988	69.9986	5320.66	5001	5000	5001	5000
80.0	5078.04	79.9994	5077.08	79.9994	79.9993	5077.08	5001	5000	5001	5000
90.0	5000.94	90.0000	5000.00	90.0000	90.0000	5000.00	5001	5000	5001	5000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

COMPARISON OF GRADIENT (GMD), WHITE SANDS (CYBER) AND SPHERICAL SLAB (VARIAN) CORRECTION METHOD*

BASED ON MEASURED VALUES CONTAINED IN JSC INTERNAL NOTE 75-FM-60 'REFRACTION CORRECTIONS FOR AN EXPONENTIAL ATMOSPHERE'

SEA LEVEL MODULUS OF REFRACTION: .0002550 SCALE HEIGHT: 7891.85 TARGET ALTITUDE: 10000 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	392550.88	-.3030	392479.09	-.3514	-.2132	392484.97	12069	9992	9665	10607
.5	329604.02	.2602	329547.82	.2492	.3012	329547.82	11383	10002	9942	10238
1.0	278818.24	.8052	278772.89	.8078	.8307	278772.82	10951	10002	10017	10126
1.5	238218.31	1.3382	238180.78	1.3458	1.3552	238180.94	10676	10002	10035	10072
2.0	205815.75	1.8629	205784.03	1.8721	1.8740	205784.34	10495	10001	10037	10041
2.5	179863.41	2.3818	179836.11	2.3914	2.3885	179836.45	10373	10001	10033	10022
3.0	158912.11	2.8966	158888.25	2.9059	2.9003	158888.55	10288	10001	10028	10011
3.5	141840.65	3.4084	141819.52	3.4172	3.4107	141819.75	10228	10001	10024	10006
4.0	127768.13	3.9180	127749.20	3.9262	3.9205	127749.36	10184	10001	10020	10006
4.5	116035.59	4.4259	116018.47	4.4335	4.4304	116018.57	10151	10000	10017	10009
5.0	106146.01	4.9325	106130.41	4.9396	4.9375	106130.44	10126	10000	10015	10010
6.0	90480.66	5.9428	90467.42	5.9490	5.9458	90467.37	10092	10000	10012	10005
7.0	78703.74	6.9506	78692.26	6.9560	6.9524	78692.18	10069	10000	10009	10003
8.0	69571.96	7.9565	69561.83	7.9613	7.9576	69561.75	10054	10000	10008	10002
9.0	62306.92	8.9612	62297.86	8.9655	8.9619	62297.79	10043	10000	10006	10001
10.0	56401.90	9.9651	56393.71	9.9689	9.9655	56393.65	10036	10000	10005	10001
12.0	47409.00	11.9709	47402.13	11.9741	11.9710	47402.09	10025	10000	10004	10000
14.0	40903.87	13.9752	40897.94	13.9779	13.9751	40897.92	10019	10000	10004	10000
16.0	35992.80	15.9784	35987.59	15.9807	15.9783	35987.57	10015	10000	10003	10000
18.0	32161.78	17.9810	32157.12	17.9830	17.9808	32157.12	10012	10000	10003	10000
20.0	29095.31	19.9830	29091.10	19.9848	19.9828	29091.09	10010	10000	10002	10000
25.0	23592.69	24.9868	23589.28	24.9881	24.9865	23589.27	10006	10000	10002	10000
30.0	19962.69	29.9894	19959.80	29.9904	29.9891	19959.80	10005	10000	10002	10000
35.0	17413.13	34.9913	17410.61	34.9921	34.9910	17410.61	10004	10000	10002	10000
40.0	15544.65	39.9927	15542.40	39.9934	39.9925	15542.40	10003	10000	10002	10000
45.0	14134.68	44.9939	14132.64	44.9945	44.9937	14132.64	10003	10000	10002	10000
50.0	13049.78	49.9949	13047.89	49.9953	49.9947	13047.89	10002	10000	10002	10000
60.0	11546.09	59.9965	11544.42	59.9968	59.9963	11544.42	10002	10000	10001	10000
70.0	10642.37	69.9978	10640.83	69.9980	69.9977	10640.83	10002	10000	10001	10000
80.0	10155.52	79.9989	10154.05	79.9990	79.9989	10154.05	10001	10000	10001	10000
90.0	10001.45	90.0000	10000.01	90.0000	90.0000	10000.00	10001	10000	10001	10000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

COMPARISON OF GRADIENT (GMD), WHITE SANDS (CYBER) AND SPHERICAL SLAB (VARIAN) CORRECTION METHODS

BASED ON MEASURED VALUES CONTAINED IN JSC INTERNAL NOTE 75-FM-60 'REFRACTION CORRECTIONS FOR AN EXPONENTIAL ATMOSPHERE'

SEA LEVEL MODULUS OF REFRACTION: .0002550 SCALE HEIGHT: 7891.85 TARGET ALTITUDE: 20000 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	548278.59	-.3702	548199.26	-.4908	-.2498	548209.40	23522	19985	18841	21134
.5	483896.25	.1992	483832.94	.1559	.2694	483834.07	22539	20002	19642	20593
1.0	428976.01	.7496	428923.95	.7368	.7963	428924.33	21875	20002	19911	20351
1.5	382189.74	1.2873	382145.91	1.2880	1.3193	382146.18	21419	20002	20010	20214
2.0	342318.67	1.8163	342281.06	1.8232	1.8380	342281.33	21098	20002	20046	20130
2.5	308314.95	2.3392	308282.16	2.3488	2.3533	308282.41	20866	20001	20056	20077
3.0	279249.06	2.8575	279220.10	2.8683	2.8663	279220.28	20694	20000	20055	20043
3.5	254352.52	3.3724	254326.65	3.3835	3.3784	254326.74	20566	20000	20052	20027
4.0	232927.71	3.8848	232904.38	3.8958	3.8903	232904.39	20469	20000	20047	20023
4.5	214401.83	4.3951	214380.61	4.4058	4.4027	214380.55	20393	20000	20042	20028
5.0	198298.26	4.9039	198278.83	4.9141	4.9113	198278.69	20333	20000	20038	20026
6.0	171854.02	5.9179	171837.42	5.9272	5.9224	171837.21	20247	20000	20030	20014
7.0	151215.66	6.9285	151201.19	6.9369	6.9314	151200.97	20189	20000	20024	20008
8.0	134774.43	7.9368	134761.62	7.9444	7.9388	134761.42	20149	20000	20020	20005
9.0	121431.30	8.9435	121419.82	8.9504	8.9448	121419.65	20120	20000	20017	20003
10.0	110422.65	9.9489	110412.25	9.9552	9.9499	110412.12	20099	20000	20014	20002
12.0	93394.58	11.9573	93385.82	11.9627	11.9578	93385.75	20070	20000	20011	20001
14.0	80896.17	13.9635	80888.61	13.9680	13.9637	80888.56	20052	20000	20008	20000
16.0	71370.24	15.9682	71363.58	15.9722	15.9682	71363.55	20040	20000	20007	20000
18.0	63890.66	17.9719	63884.71	17.9754	17.9718	63884.69	20032	20000	20006	20000
20.0	57875.86	19.9748	57870.48	19.9780	19.9748	57870.46	20026	20000	20005	20000
25.0	47027.34	24.9804	47022.97	24.9828	24.9802	47022.96	20017	20000	20004	20000
30.0	39836.95	29.9841	39833.25	29.9861	29.9840	39833.25	20011	20000	20003	20000
35.0	34773.07	34.9869	34769.85	34.9885	34.9868	34769.84	20008	20000	20003	20000
40.0	31055.67	39.9891	31052.79	39.9904	39.9889	31052.79	20006	20000	20002	20000
45.0	28247.36	44.9909	28244.74	44.9920	44.9907	28244.74	20005	20000	20002	20000
50.0	26084.85	49.9924	26082.43	49.9933	49.9922	26082.43	20004	20000	20002	20000
60.0	23085.37	59.9948	23083.23	59.9954	59.9946	23083.23	20003	20000	20002	20000
70.0	21281.58	69.9967	21279.61	69.9971	69.9966	21279.61	20002	20000	20002	20000
80.0	20309.53	79.9984	20307.65	79.9986	79.9984	20307.65	20002	20000	20002	20000
90.0	20001.85	90.0000	20000.00	90.0000	90.0000	20000.00	20002	20000	20002	20000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

COMPARISON OF GRADIENT (GMD), WHITE SANDS (CYBER) AND SPHERICAL SLAB (VARIAN) CORRECTION METHODS

BASED ON MEASURED VALUES CONTAINED IN JSC INTERNAL NOTE 75-FM-60 'REFRACTION CORRECTIONS FOR AN EXPONENTIAL ATMOSPHERE'

SEA LEVEL MODULUS OF REFRACTION: .0002550 SCALE HEIGHT: 7891.85 TARGET ALTITUDE: 50000 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	850619.23	-.4406	850536.97	-.7615	-.3200	850549.26	56471	49973	45256	51752
.5	785027.35	.1383	784961.58	.0050	.1981	784962.12	54925	50002	48197	50814
1.0	726547.93	.6959	726493.68	.6340	.7353	726493.54	53834	50002	49231	50499
1.5	674119.01	1.2393	674073.18	1.2101	1.2661	674072.99	53050	50002	49668	50315
2.0	626895.67	1.7729	626856.21	1.7604	1.7906	626856.08	52471	50002	49871	50194
2.5	584253.33	2.2996	584218.81	2.2960	2.3105	584218.71	52032	50002	49970	50112
3.0	545672.56	2.8211	545641.98	2.8226	2.8272	545641.84	51691	49999	50017	50056
3.5	510767.64	3.3389	510740.24	3.3432	3.3426	510740.05	51426	49999	50041	50032
4.0	479139.08	3.8537	479114.31	3.8596	3.8577	479114.06	51214	49999	50052	50033
4.5	450449.96	4.3661	450427.38	4.3730	4.3734	450427.08	51044	50000	50056	50056
5.0	424395.85	4.8768	424375.13	4.8841	4.8837	424374.78	50905	50000	50056	50050
6.0	379119.42	5.8940	379101.66	5.9015	5.8982	379101.27	50695	50000	50052	50027
7.0	341423.78	6.9073	341408.27	6.9145	6.9099	341407.90	50547	50000	50045	50015
8.0	309798.46	7.9177	309784.70	7.9246	7.9195	309784.38	50440	50000	50039	50009
9.0	283047.94	8.9261	283035.59	8.9326	8.9274	283035.33	50360	50000	50034	50006
10.0	260232.76	9.9331	260221.56	9.9391	9.9340	260221.35	50299	50000	50029	50004
12.0	223617.64	11.9439	223608.20	11.9491	11.9443	223608.07	50215	50000	50022	50002
14.0	195742.91	13.9518	195734.75	13.9564	13.9521	195734.66	50161	50000	50018	50001
16.0	173956.67	15.9579	173949.48	15.9620	15.9580	173949.42	50124	50000	50014	50001
18.0	156541.85	17.9627	156535.42	17.9664	17.9628	156535.38	50098	50000	50012	50000
20.0	142352.81	19.9667	142346.99	19.9699	19.9667	142346.96	50079	50000	50010	50000
25.0	116380.39	24.9739	116375.67	24.9765	24.9739	116375.65	50050	50000	50007	50000
30.0	98925.13	29.9789	98921.13	29.9810	29.9788	98921.12	50033	50000	50005	50000
35.0	86531.95	34.9826	86528.46	34.9843	34.9825	86528.45	50024	50000	50004	50000
40.0	77387.40	39.9855	77384.28	39.9869	39.9854	77384.28	50017	50000	50004	50000
45.0	70455.48	44.9878	70452.65	44.9890	44.9877	70452.64	50013	50000	50003	50000
50.0	65104.91	49.9898	65102.29	49.9908	49.9897	65102.29	50009	50000	50003	50000
60.0	57666.77	59.9930	57664.45	59.9936	59.9929	57664.45	50006	50000	50002	50000
70.0	53185.14	69.9956	53183.01	69.9960	69.9955	53183.00	50003	50000	50002	50000
80.0	50767.57	79.9979	50765.53	79.9981	79.9978	50765.53	50002	50000	50002	50000
90.0	50002.01	90.0000	50000.00	90.0000	90.0000	50000.00	50002	50000	50002	50000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

COMPARISON OF GRADIENT (GMD), WHITE SANDS (CYBER) AND SPHERICAL SLAB (VARIAN) CORRECTION METHODS

BASED ON MEASURED VALUES CONTAINED IN JSC INTERNAL NOTE 75-FM-60 'REFRACTION CORRECTIONS FOR AN EXPONENTIAL ATMOSPHERE'

SEA LEVEL MODULUS OF REFRACTION: .0002550 SCALE HEIGHT: 7891.85 TARGET ALTITUDE: 100000 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	1188162.14	-.4778	1188079.25	-1.0637	-.3634	1188092.14	109725	99963	88005	102300
.5	1121980.82	.1080	1121914.68	-.1278	.1520	1121914.52	107568	100003	95467	100851
1.0	1061752.84	.6705	1061698.37	.5550	.6983	1061697.76	106022	100004	97906	100511
1.5	1006472.12	1.2175	1006426.15	1.1555	1.2358	1006425.65	104894	100004	98939	100319
2.0	955381.62	1.7539	955342.06	1.7191	1.7652	955341.72	104047	100003	99439	100188
2.5	907968.98	2.2828	907934.39	2.2630	2.2886	907934.14	103394	100003	99701	100094
3.0	863840.16	2.8061	863809.53	2.7952	2.8082	863809.28	102878	99999	99842	100029
3.5	822750.03	3.3253	822722.60	3.3197	3.3258	822722.32	102470	100000	99926	100006
4.0	784431.18	3.8413	784406.38	3.8391	3.8429	784406.06	102139	100000	99975	100022
4.5	748675.09	4.3548	748652.49	4.3547	4.3605	748652.13	101867	100000	100004	100074
5.0	715295.01	4.8663	715274.27	4.8677	4.8720	715273.87	101641	100000	100021	100071
6.0	654992.51	5.8849	654974.74	5.8877	5.8882	654974.31	101293	100000	100036	100038
7.0	602299.32	6.8992	602283.80	6.9027	6.9012	602283.39	101040	100001	100039	100021
8.0	556150.08	7.9105	556136.32	7.9141	7.9118	556135.97	100851	100001	100038	100013
9.0	515617.73	8.9196	515605.38	8.9233	8.9205	515605.09	100707	100001	100035	100008
10.0	479901.36	9.9272	479890.16	9.9307	9.9277	479889.92	100595	100001	100032	100005
12.0	420272.52	11.9388	420263.08	11.9421	11.9391	420262.93	100435	100000	100026	100002
14.0	372917.52	13.9474	372909.36	13.9504	13.9476	372909.26	100330	100000	100021	100001
16.0	334721.29	15.9541	334714.10	15.9567	15.9541	334714.03	100257	100000	100017	100001
18.0	303454.98	17.9593	303448.55	17.9617	17.9593	303448.49	100204	100000	100014	100000
20.0	277512.77	19.9636	277506.95	19.9657	19.9636	277506.91	100166	100000	100012	100000
25.0	228998.10	24.9715	228993.38	24.9732	24.9714	228993.35	100104	100000	100009	100000
30.0	195704.20	29.9769	195700.20	29.9783	29.9768	195700.18	100070	100000	100006	100000
35.0	171764.65	34.9809	171761.16	34.9821	34.9809	171761.15	100048	100000	100005	100000
40.0	153955.67	39.9841	153952.55	39.9851	39.9840	153952.54	100034	100000	100004	100000
45.0	140381.00	44.9866	140378.17	44.9875	44.9866	140378.16	100025	100000	100004	100000
50.0	129862.38	49.9888	129859.76	49.9895	49.9887	129859.75	100018	100000	100003	100000
60.0	115185.63	59.9923	115183.31	59.9928	59.9922	115183.31	100010	100000	100003	100000
70.0	106314.57	69.9951	106312.44	69.9954	69.9951	106312.43	100005	100000	100002	100000
80.0	101521.08	79.9976	101519.04	79.9978	79.9976	101519.04	100003	100000	100002	100000
90.0	100002.01	90.0000	100000.00	90.0000	90.0000	100000.00	100002	100000	100002	100000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

APPENDIX B

TABULATED REFRACTION COMPARISON DATA FOR SEA-LEVEL MODULUS OF REFRACTION OF 0.0003307

COMPARISON OF GRADIENT (GMD), WHITE SANDS (CYBER) AND SPHERICAL SLAB (VARIAN) CORRECTION METHODS

BASED ON MEASURED VALUES CONTAINED IN JSC INTERNAL NOTE 75-FM-60 'REFRACTION CORRECTIONS FOR AN EXPONENTIAL ATMOSPHERE'

SEA LEVEL MODULUS OF REFRACTION: .0003307 SCALE HEIGHT: 6631.54 TARGET ALTITUDE: 1000 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	135871.48	-.1883	135828.48	-.2088	-.1913	135821.22	1447	1000	952	993
.5	77318.02	.3950	77294.06	.3874	.3912	77292.22	1143	1001	991	996
1.0	49618.93	.9333	49603.64	.9288	.9336	49603.21	1059	1001	997	1001
1.5	35574.52	1.4525	35563.58	1.4492	1.4533	35563.50	1030	1001	999	1001
2.0	27481.63	1.9635	27473.19	1.9608	1.9638	27473.19	1018	1000	999	1001
2.5	22310.27	2.4706	22303.42	2.4683	2.4702	22303.44	1012	1000	1000	1000
3.0	18746.94	2.9754	18741.18	2.9734	2.9747	18741.21	1009	1000	1000	1000
3.5	16152.57	3.4790	16147.61	3.4771	3.4781	16147.63	1006	1000	1000	1000
4.0	14183.03	3.9817	14178.68	3.9799	3.9811	14178.69	1005	1000	1000	1000
4.5	12638.74	4.4838	12634.86	4.4821	4.4838	12634.87	1004	1000	1000	1000
5.0	11396.35	4.9855	11392.85	4.9839	4.9848	11392.85	1003	1000	1000	1000
6.0	9522.77	5.9880	9519.85	5.9865	5.9873	9519.85	1002	1000	1000	1000
7.0	8178.45	6.9899	8175.94	6.9885	6.9891	8175.94	1002	1000	1000	1000
8.0	7167.70	7.9912	7165.50	7.9899	7.9904	7165.50	1001	1000	1000	1000
9.0	6380.53	8.9923	6378.57	8.9910	8.9915	6378.57	1001	1000	1000	1000
10.0	5750.44	9.9932	5748.68	9.9920	9.9923	5748.67	1001	1000	1000	1000
12.0	4805.40	11.9945	4803.93	11.9933	11.9936	4803.92	1001	1000	1000	1000
14.0	4131.20	13.9954	4129.93	13.9943	13.9946	4129.93	1001	1000	1000	1000
16.0	3626.66	15.9961	3625.55	15.9950	15.9953	3625.55	1001	1000	1000	1000
18.0	3235.39	17.9967	3234.40	17.9956	17.9958	3234.40	1001	1000	1000	1000
20.0	2923.49	19.9971	2922.59	19.9961	19.9963	2922.59	1000	1000	1000	1000
25.0	2366.33	24.9979	2365.60	24.9970	24.9971	2365.60	1000	1000	1000	1000
30.0	2000.29	29.9984	1999.68	29.9975	29.9976	1999.68	1000	1000	1000	1000
35.0	1743.79	34.9987	1743.26	34.9980	34.9981	1743.25	1000	1000	1000	1000
40.0	1556.08	39.9990	1555.60	39.9983	39.9984	1555.60	1000	1000	1000	1000
45.0	1414.57	44.9993	1414.14	44.9986	44.9986	1414.14	1000	1000	1000	1000
50.0	1305.76	49.9994	1305.36	49.9988	49.9989	1305.36	1000	1000	1000	1000
60.0	1155.03	59.9996	1154.68	59.9992	59.9992	1154.68	1000	1000	1000	1000
70.0	1064.50	69.9998	1064.18	69.9995	69.9995	1064.17	1000	1000	1000	1000
80.0	1015.74	79.9999	1015.43	79.9997	79.9998	1015.43	1000	1000	1000	1000
90.0	1000.31	90.0000	1000.01	90.0000	90.0000	1000.00	1000	1000	1000	1000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

COMPARISON OF GRADIENT (GMD), WHITE SANDS (CYBER) AND SPHERICAL SLAB (VARIAN) CORRECTION METHODS

BASED ON MEASURED VALUES CONTAINED IN JSC INTERNAL NOTE 75-FM-60 'REFRACTION CORRECTIONS FOR AN EXPONENTIAL ATMOSPHERE'

SEA LEVEL MODULUS OF REFRACTION: .0003307 SCALE HEIGHT: 6631.54 TARGET ALTITUDE: 2000 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	191171.30	-.2593	191113.26	-.2937	-.2611	191110.61	2864	1998	1885	1992
.5	127041.86	.3327	127004.60	.3209	.3242	127001.83	2373	2002	1976	1983
1.0	89279.74	.8840	89253.92	.8782	.8851	89253.10	2183	2001	1993	2003
1.5	66915.51	1.4137	66896.27	1.4100	1.4162	66896.12	2102	2001	1997	2004
2.0	52869.41	1.9322	52854.25	1.9294	1.9338	52854.29	2064	2001	1999	2002
2.5	43456.83	2.4445	43444.39	2.4422	2.4449	43444.47	2043	2001	1999	2001
3.0	36787.43	2.9532	36776.91	2.9512	2.9527	36776.98	2031	2000	2000	2000
3.5	31846.95	3.4596	31837.85	3.4578	3.4590	31837.90	2023	2000	2000	2000
4.0	28053.07	3.9646	28045.05	3.9629	3.9644	28045.09	2018	2000	2000	2000
4.5	25054.65	4.4685	25047.49	4.4669	4.4694	25047.51	2015	2000	2000	2001
5.0	22628.67	4.9716	22622.21	4.9701	4.9717	22622.21	2012	2000	2000	2000
6.0	18949.42	5.9764	18944.01	5.9751	5.9761	18944.00	2009	2000	2000	2000
7.0	16295.92	6.9799	16291.27	6.9786	6.9794	16291.26	2006	2000	2000	2000
8.0	14294.36	7.9825	14290.28	7.9813	7.9819	14290.27	2005	2000	2000	2000
9.0	12732.14	8.9845	12728.51	8.9834	8.9839	12728.50	2004	2000	2000	2000
10.0	11479.75	9.9862	11476.47	9.9850	9.9855	11476.47	2003	2000	2001	2000
12.0	9598.55	11.9887	9595.81	11.9876	11.9879	9595.81	2003	2000	2001	2000
14.0	8254.69	13.9904	8252.33	13.9894	13.9897	8252.33	2002	2000	2001	2000
16.0	7248.15	15.9918	7246.08	15.9908	15.9910	7246.08	2002	2000	2001	2000
18.0	6467.15	17.9928	6465.30	17.9919	17.9921	6465.30	2001	2000	2001	2000
20.0	5844.36	19.9937	5842.69	19.9927	19.9929	5842.69	2001	2000	2001	2000
25.0	4731.33	24.9952	4729.98	24.9943	24.9945	4729.98	2001	2000	2001	2000
30.0	3999.80	29.9962	3998.66	29.9954	29.9955	3998.66	2001	2000	2001	2000
35.0	3487.10	34.9970	3486.11	34.9962	34.9963	3486.10	2001	2000	2001	2000
40.0	3111.84	39.9975	3110.95	39.9968	39.9969	3110.95	2001	2000	2001	2000
45.0	2828.92	44.9980	2828.11	44.9974	44.9974	2828.11	2001	2000	2001	2000
50.0	2611.35	49.9984	2610.61	49.9978	49.9978	2610.60	2001	2000	2001	2000
60.0	2309.97	59.9989	2309.31	59.9985	59.9985	2309.31	2001	2000	2001	2000
70.0	2128.93	69.9993	2128.32	69.9990	69.9991	2128.32	2001	2000	2001	2000
80.0	2031.43	79.9997	2030.85	79.9995	79.9995	2030.85	2001	2000	2001	2000
90.0	2000.43	90.0000	1999.86	90.0000	90.0000	1999.86	2000	2000	2000	2000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

COMPARISON OF GRADIENT (GMD), WHITE SANDS (CYBER) AND SPHERICAL SLAB (VARIAN) CORRECTION METHODS

BASED ON MEASURED VALUES CONTAINED IN JSC INTERNAL NOTE 75-FM-60 'REFRACTION CORRECTIONS FOR AN EXPONENTIAL ATMOSPHERE'

SEA LEVEL MODULUS OF REFRACTION: .0003307 SCALE HEIGHT: 6631.54 TARGET ALTITUDE: 5000 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	298306.60	-.3799	298225.86	-.4583	-.3254	298233.94	6972	4993	4588	5276
.5	229152.64	.2226	229094.40	.1971	.2174	229092.36	6113	5002	4903	4982
1.0	179723.87	.7886	179679.75	.7799	.7905	179679.05	5666	5002	4976	5008
1.5	144662.69	1.3327	144627.87	1.3300	1.3374	144627.93	5425	5002	4996	5013
2.0	119495.85	1.8633	119467.41	1.8629	1.8670	119467.74	5288	5001	5002	5009
2.5	101023.66	2.3852	100999.79	2.3858	2.3869	101000.14	5205	5001	5003	5004
3.0	87104.47	2.9016	87083.98	2.9024	2.9017	87084.26	5151	5001	5003	5001
3.5	76352.98	3.4140	76335.07	3.4150	3.4137	76335.27	5116	5001	5003	5000
4.0	67848.80	3.9239	67832.92	3.9248	3.9245	67833.04	5092	5001	5003	5001
4.5	60982.52	4.4318	60968.27	4.4327	4.4348	60968.33	5074	5001	5003	5004
5.0	55338.44	4.9383	55325.52	4.9391	4.9411	55325.53	5061	5001	5003	5003
6.0	46638.32	5.9482	46627.45	5.9489	5.9497	46627.41	5044	5000	5002	5002
7.0	40268.39	6.9555	40259.01	6.9561	6.9562	40258.96	5033	5000	5002	5001
8.0	35416.45	7.9611	35408.21	7.9615	7.9613	35408.16	5025	5000	5002	5001
9.0	31604.31	8.9654	31596.96	8.9658	8.9654	31596.92	5020	5000	5002	5000
10.0	28533.77	9.9690	28527.14	9.9692	9.9688	28527.11	5017	5000	5002	5000
12.0	23900.03	11.9743	23894.48	11.9744	11.9739	23894.46	5012	5000	5001	5000
14.0	20575.95	13.9781	20571.17	13.9781	13.9776	20571.16	5009	5000	5001	5000
16.0	18079.69	15.9811	18075.49	15.9810	15.9805	18075.48	5007	5000	5001	5000
18.0	16139.36	17.9833	16135.61	17.9832	17.9828	16135.61	5006	5000	5001	5000
20.0	14590.17	19.9852	14586.78	19.9850	19.9846	14586.78	5005	5000	5001	5000
25.0	11817.83	24.9885	11815.09	24.9883	24.9879	11815.08	5003	5000	5001	5000
30.0	9993.53	29.9908	9991.21	29.9905	29.9903	9991.21	5003	5000	5001	5000
35.0	8714.05	34.9925	8712.03	34.9922	34.9920	8712.03	5002	5000	5001	5000
40.0	7777.19	39.9938	7775.39	39.9935	39.9933	7775.38	5002	5000	5001	5000
45.0	7070.64	44.9948	7069.00	44.9945	44.9944	7069.00	5002	5000	5001	5000
50.0	6527.20	49.9957	6525.69	49.9954	49.9953	6525.68	5002	5000	5001	5000
60.0	5774.28	59.9971	5772.94	59.9968	59.9967	5772.94	5001	5000	5001	5000
70.0	5321.92	69.9982	5320.69	69.9980	69.9979	5320.68	5001	5000	5001	5000
80.0	5078.27	79.9991	5077.09	79.9990	79.9990	5077.09	5001	5000	5001	5000
90.0	5001.16	90.0000	5000.00	90.0000	90.0000	5000.00	5001	5000	5001	5000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

COMPARISON OF GRADIENT (GMD), WHITE SANDS (CYBER) AND SPHERICAL SLAB (VARIAN) CORRECTION METHODS

BASED ON MEASURED VALUES CONTAINED IN JSC INTERNAL NOTE 75-FM-60 'REFRACTION CORRECTIONS FOR AN EXPONENTIAL ATMOSPHERE'

SEA LEVEL MODULUS OF REFRACTION: .0003307 SCALE HEIGHT: 6631.54 TARGET ALTITUDE: 10000 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	414831.76	-.4823	414736.25	-.6374	-.3709	414753.81	13476	9985	8869	10791
.5	343319.55	.1292	343247.62	.0756	.1666	343248.89	12224	10002	9686	10226
1.0	287486.54	.7044	287429.88	.6861	.7271	287430.66	11486	10002	9914	10116
1.5	243847.66	1.2575	243801.50	1.2532	1.2732	243802.35	11035	10002	9987	10069
2.0	209571.06	1.7962	209532.45	1.7980	1.8065	209533.28	10748	10002	10011	10039
2.5	182437.63	2.3254	182404.63	2.3298	2.3311	182405.31	10558	10002	10018	10020
3.0	160721.61	2.8480	160692.91	2.8534	2.8505	160693.40	10428	10001	10018	10008
3.5	143147.87	3.3658	143122.55	3.3715	3.3670	143122.84	10337	10001	10017	10004
4.0	128735.18	3.8801	128712.56	3.8858	3.8824	128712.69	10271	10001	10016	10006
4.5	116766.66	4.3918	116746.25	4.3974	4.3974	116746.27	10222	10001	10014	10012
5.0	106709.60	4.9016	106691.02	4.9069	4.9081	106690.96	10185	10001	10012	10013
6.0	90833.09	5.9168	90817.36	5.9216	5.9206	90817.21	10133	10001	10010	10007
7.0	78936.99	6.9281	78923.37	6.9324	6.9304	78923.21	10100	10001	10008	10004
8.0	69733.56	7.9368	69721.56	7.9406	7.9382	69721.42	10078	10000	10007	10002
9.0	62423.14	8.9437	62412.41	8.9471	8.9446	62412.31	10063	10000	10006	10001
10.0	56488.11	9.9493	56478.41	9.9524	9.9498	56478.34	10051	10000	10005	10001
12.0	47460.07	11.9578	47451.94	11.9604	11.9579	47451.89	10036	10000	10004	10000
14.0	40936.50	13.9640	40929.49	13.9662	13.9639	40929.46	10027	10000	10003	10000
16.0	36014.88	15.9687	36008.72	15.9705	15.9685	36008.70	10021	10000	10003	10000
18.0	32177.39	17.9724	32171.89	17.9740	17.9721	32171.87	10017	10000	10003	10000
20.0	29106.76	19.9754	29101.78	19.9767	19.9750	29101.77	10014	10000	10003	10000
25.0	23598.61	24.9809	23594.58	24.9818	24.9805	23594.57	10009	10000	10002	10000
30.0	19966.15	29.9846	19962.74	29.9853	29.9842	19962.74	10006	10000	10002	10000
35.0	17415.33	34.9873	17412.36	34.9879	34.9869	17412.35	10005	10000	10002	10000
40.0	15546.14	39.9895	15543.49	39.9899	39.9891	15543.48	10004	10000	10002	10000
45.0	14135.75	44.9912	14133.34	44.9915	44.9909	14133.34	10003	10000	10002	10000
50.0	13050.58	49.9926	13048.35	49.9929	49.9923	13048.35	10003	10000	10002	10000
60.0	11546.58	59.9950	11544.61	59.9951	59.9947	11544.61	10002	10000	10002	10000
70.0	10642.72	69.9968	10640.90	69.9969	69.9967	10640.90	10002	10000	10002	10000
80.0	10155.80	79.9985	10154.07	79.9985	79.9984	10154.07	10002	10000	10002	10000
90.0	10001.71	90.0000	10000.00	90.0000	90.0000	10000.00	10002	10000	10002	10000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

COMPARISON OF GRADIENT (GMD), WHITE SANDS (CYBER) AND SPHERICAL SLAB (VARIAN) CORRECTION METHODS

BASED ON MEASURED VALUES CONTAINED IN JSC INTERNAL NOTE 75-FM-60 'REFRACTION CORRECTIONS FOR AN EXPONENTIAL ATMOSPHERE'

SEA LEVEL MODULUS OF REFRACTION: .0003307 SCALE HEIGHT: 6631.54 TARGET ALTITUDE: 20000 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	573683.54	-.5779	573579.63	-.8814	-.4455	573603.62	25748	19974	16952	21297
.5	500651.97	.0447	500572.63	-.0680	.0973	500575.58	23973	20002	19027	20460
1.0	440432.58	.6286	440369.16	.5832	.6617	440370.83	22852	20002	19659	20256
1.5	390259.46	1.1891	390207.08	1.1722	1.2115	390208.38	22117	20002	19892	20154
2.0	348138.04	1.7342	348093.69	1.7307	1.7487	348094.73	21614	20002	19984	20090
2.5	312596.55	2.2690	312558.26	2.2721	2.2772	312559.01	21260	20002	20022	20046
3.0	282451.67	2.7965	282418.09	2.8029	2.8003	282418.53	21002	20000	20035	20019
3.5	256791.90	3.3186	256762.07	3.3266	3.3206	256762.25	20812	20000	20039	20009
4.0	234814.60	3.8367	234787.81	3.8454	3.8399	234787.78	20669	20000	20039	20013
4.5	215882.48	4.3517	215858.19	4.3607	4.3593	215858.03	20558	20000	20037	20029
5.0	199475.77	4.8644	199453.58	4.8733	4.8733	199453.32	20472	20000	20034	20031
6.0	172626.25	5.8845	172607.36	5.8929	5.8899	172607.02	20348	20000	20028	20016
7.0	151744.07	6.8996	151727.65	6.9074	6.9030	151727.33	20266	20000	20023	20009
8.0	135149.28	7.9114	135134.77	7.9186	7.9137	135134.51	20209	20000	20019	20006
9.0	121705.50	8.9208	121692.51	8.9274	8.9224	121692.31	20168	20000	20016	20004
10.0	110628.54	9.9285	110616.78	9.9346	9.9296	110616.63	20138	20000	20014	20002
12.0	93518.36	11.9403	93508.48	11.9455	11.9408	93508.38	20097	20000	20011	20001
14.0	80975.81	13.9489	80967.28	13.9534	13.9491	80967.22	20072	20000	20009	20001
16.0	71424.22	15.9555	71416.72	15.9594	15.9555	71416.68	20056	20000	20007	20000
18.0	63928.78	17.9607	63922.07	17.9641	17.9606	63922.05	20044	20000	20006	20000
20.0	57903.68	19.9649	57897.61	19.9679	19.9648	57897.59	20036	20000	20005	20000
25.0	47041.46	24.9726	47036.54	24.9749	24.9724	47036.53	20023	20000	20004	20000
30.0	39844.96	29.9779	39840.80	29.9797	29.9776	39840.79	20016	20000	20003	20000
35.0	34777.96	34.9818	34774.33	34.9833	34.9815	34774.33	20011	20000	20003	20000
40.0	31058.83	39.9848	31055.59	39.9860	39.9846	31055.59	20008	20000	20003	20000
45.0	28249.49	44.9873	28246.54	44.9883	44.9871	28246.54	20007	20000	20003	20000
50.0	26086.33	49.9893	26083.61	49.9902	49.9891	26083.61	20005	20000	20002	20000
60.0	23086.13	59.9927	23083.72	59.9932	59.9925	23083.72	20004	20000	20002	20000
70.0	21282.00	69.9954	21279.78	69.9957	69.9953	21279.78	20003	20000	20002	20000
80.0	20309.81	79.9978	20307.69	79.9979	79.9977	20307.69	20002	20000	20002	20000
90.0	20002.09	90.0000	20000.01	90.0000	90.0000	20000.00	20002	20000	20002	20000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

COMPARISON OF GRADIENT (GMD), WHITE SANDS (CYBER) AND SPHERICAL SLAB (VARIAN) CORRECTION METHODS

BASED ON MEASURED VALUES CONTAINED IN JSC INTERNAL NOTE 75-FM-60 'REFRACTION CORRECTIONS FOR AN EXPONENTIAL ATMOSPHERE'

SEA LEVEL MODULUS OF REFRACTION: .0003307 SCALE HEIGHT: 6631.54 TARGET ALTITUDE: 50000 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	878563.13	-.6747	878455.62	-1.3499	-.5537	878482.82	60225	49954	39689	51799
.5	804288.45	-.0358	804206.57	-.2875	-.0177	804208.49	57470	50001	46505	50254
1.0	740413.56	.5595	740348.14	.4446	.5687	740348.84	55655	50002	48536	50120
1.5	684451.21	1.1285	684397.14	1.0714	1.1342	684397.83	54410	50002	49332	50070
2.0	634797.11	1.6803	634751.28	1.6514	1.6827	634751.90	53519	50002	49690	50028
2.5	590419.43	2.2205	590379.81	2.2065	2.2193	590380.23	52862	50002	49865	49990
3.0	550557.68	2.7523	550522.88	2.7468	2.7487	550523.06	52361	49998	49950	49964
3.5	514696.18	3.2781	514665.22	3.2775	3.2743	514665.16	51977	49999	49998	49965
4.0	482335.36	3.7994	482307.52	3.8017	3.7986	482307.28	51674	49999	50022	49992
4.5	453077.14	4.3172	453051.87	4.3213	4.3228	453051.52	51433	49999	50035	50044
5.0	426575.04	4.8323	426551.93	4.8374	4.8403	426551.50	51237	50000	50041	50058
6.0	380655.31	5.8563	380635.60	5.8624	5.8611	380635.12	50945	50000	50043	50031
7.0	342537.03	6.8747	342519.88	6.8809	6.8777	342519.45	50741	50000	50039	50018
8.0	310625.15	7.8890	310609.98	7.8951	7.8910	310609.63	50594	50000	50035	50011
9.0	283675.10	8.9006	283661.50	8.9064	8.9020	283661.23	50485	50000	50031	50007
10.0	260717.55	9.9101	260705.24	9.9155	9.9110	260705.03	50403	50000	50027	50004
12.0	223921.63	11.9247	223911.27	11.9295	11.9252	223911.15	50288	50000	50021	50002
14.0	195943.95	13.9354	195935.01	13.9397	13.9357	195934.93	50215	50000	50017	50001
16.0	174095.46	15.9436	174087.59	15.9474	15.9438	174087.53	50166	50000	50014	50001
18.0	156641.05	17.9501	156634.01	17.9535	17.9502	156633.97	50131	50000	50011	50000
20.0	142425.79	19.9554	142419.42	19.9585	19.9554	142419.39	50106	50000	50010	50000
25.0	116417.69	24.9651	116412.53	24.9675	24.9650	116412.51	50066	50000	50007	50000
30.0	98946.19	29.9718	98941.82	29.9737	29.9717	98941.81	50044	50000	50005	50000
35.0	86544.67	34.9767	86540.86	34.9783	34.9766	86540.85	50031	50000	50004	50000
40.0	77395.44	39.9806	77392.04	39.9819	39.9805	77392.03	50022	50000	50004	50000
45.0	70460.73	44.9837	70457.63	44.9848	44.9836	70457.63	50016	50000	50003	50000
50.0	65108.41	49.9863	65105.55	49.9873	49.9862	65105.55	50012	50000	50003	50000
60.0	57668.35	59.9906	57665.82	59.9912	59.9905	57665.82	50007	50000	50003	50000
70.0	53185.84	69.9941	53183.51	69.9945	69.9940	53183.51	50004	50000	50002	50000
80.0	50767.87	79.9971	50765.65	79.9973	79.9971	50765.64	50003	50000	50002	50000
90.0	50002.19	90.0000	50000.00	90.0000	90.0000	50000.00	50002	50000	50002	50000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

COMPARISON OF GRADIENT (GMD), WHITE SANDS (CYBER) AND SPHERICAL SLAB (VARIAN) CORRECTION METHODS

BASED ON MEASURED VALUES CONTAINED IN JSC INTERNAL NOTE 75-FM-60 'REFRACTION CORRECTIONS FOR AN EXPONENTIAL ATMOSPHERE'

SEA LEVEL MODULUS OF REFRACTION: .0003307 SCALE HEIGHT: 6631.54 TARGET ALTITUDE: 100000 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	1217288.16	-.7261	1217179.38	-1.8703	-.6148	1217207.77	115122	99934	75979	102265
.5	1142417.30	-.0758	1142334.76	-.4706	-.0830	1142337.33	111309	100001	92261	99861
1.0	1076774.52	.5272	1076708.72	.3446	.5190	1076708.62	108757	100003	96635	99851
1.5	1017929.38	1.1015	1017875.08	1.0053	1.0952	1017875.31	106978	100003	98331	99893
2.0	964367.07	1.6572	964321.09	1.6029	1.6510	964321.44	105686	100003	99111	99900
2.5	915169.95	2.2004	915130.22	2.1685	2.1928	915130.48	104716	100002	99508	99884
3.0	869704.42	2.7345	869669.55	2.7155	2.7260	869669.61	103964	99997	99720	99870
3.5	827598.81	3.2622	827567.80	3.2510	3.2547	827567.66	103378	99998	99844	99891
4.0	788486.90	3.7850	788459.02	3.7787	3.7815	788458.73	102909	99998	99918	99951
4.5	752100.64	4.3041	752075.34	4.3009	4.3081	752074.95	102528	99999	99963	100051
5.0	718212.55	4.8202	718189.42	4.8191	4.8272	718188.95	102214	99999	99990	100086
6.0	657153.64	5.8459	657133.92	5.8472	5.8500	657133.41	101734	100000	100017	100045
7.0	603937.46	6.8655	603920.30	6.8678	6.8681	603919.85	101389	100000	100027	100026
8.0	557415.60	7.8809	557400.42	7.8837	7.8826	557400.06	101133	100000	100029	100015
9.0	516611.36	8.8933	516597.76	8.8962	8.8944	516597.48	100939	100000	100029	100010
10.0	480692.61	9.9034	480680.29	9.9064	9.9042	480680.08	100789	100000	100027	100006
12.0	420792.89	11.9191	420782.53	11.9219	11.9195	420782.40	100575	100000	100023	100003
14.0	373274.02	13.9306	373265.08	13.9331	13.9308	373264.99	100435	100000	100019	100001
16.0	334973.94	15.9394	334966.07	15.9417	15.9395	334966.01	100338	100000	100016	100001
18.0	303639.19	17.9463	303632.15	17.9485	17.9464	303632.11	100269	100000	100013	100000
20.0	277650.34	19.9520	277643.97	19.9539	19.9520	277643.94	100218	100000	100011	100000
25.0	229070.13	24.9624	229064.97	24.9640	24.9624	229064.95	100137	100000	100008	100000
30.0	195745.38	29.9696	195741.01	29.9709	29.9695	195741.00	100091	100000	100006	100000
35.0	171789.66	34.9749	171785.85	34.9759	34.9748	171785.84	100063	100000	100005	100000
40.0	153971.50	39.9790	153968.10	39.9799	39.9790	153968.09	100045	100000	100004	100000
45.0	140391.31	44.9824	140388.21	44.9831	44.9824	140388.21	100032	100000	100004	100000
50.0	129869.19	49.9852	129866.33	49.9859	49.9852	129866.33	100023	100000	100003	100000
60.0	115188.61	59.9898	115186.08	59.9903	59.9898	115186.08	100012	100000	100003	100000
70.0	106315.79	69.9936	106313.46	69.9939	69.9936	106313.46	100006	100000	100002	100000
80.0	101521.49	79.9969	101519.27	79.9970	79.9969	101519.26	100003	100000	100002	100000
90.0	100002.19	90.0000	100000.00	90.0000	90.0000	100000.00	100002	100000	100002	100000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

APPENDIX C

TABULATED REFRACTION COMPARISON DATA FOR SEA-LEVEL MODULUS OF REFRACTION OF 0.0003860

COMPARISON OF GRADIENT (GMD), WHITE SANDS (CYBER) AND SPHERICAL SLAB (VARIAN) CORRECTION METHODS

BASED ON MEASURED VALUES CONTAINED IN JSC INTERNAL NOTE 75-FM-60 'REFRACTION CORRECTIONS FOR AN EXPONENTIAL ATMOSPHERE'

SEA LEVEL MODULUS OF REFRACTION: .0003860 SCALE HEIGHT: 5610.93 TARGET ALTITUDE: 1000 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	148875.73	-.2836	148820.91	*******	-.2872	148815.71	1737	1000	*******	990
.5	80619.94	.3502	80591.10	*******	.3446	80588.01	1213	1002	*******	994
1.0	50596.50	.9069	50578.53	*******	.9073	50577.81	1084	1001	*******	1001
1.5	35950.45	1.4344	35937.71	*******	1.4355	35937.55	1042	1001	*******	1001
2.0	27658.47	1.9498	27648.68	*******	1.9502	27648.66	1025	1001	*******	1001
2.5	22406.06	2.4596	22398.13	*******	2.4591	22398.15	1017	1000	*******	1000
3.0	18804.16	2.9663	18797.51	*******	2.9653	18797.53	1012	1000	*******	1000
3.5	16189.44	3.4712	16183.72	*******	3.4700	16183.73	1009	1000	*******	1000
4.0	14208.17	3.9749	14203.15	*******	3.9741	14203.15	1007	1000	*******	1000
4.5	12656.65	4.4778	12652.18	*******	4.4778	12652.18	1006	1000	*******	1000
5.0	11409.57	4.9801	11405.54	*******	4.9792	11405.53	1005	1000	*******	1000
6.0	9530.61	5.9836	9527.24	*******	5.9826	9527.24	1003	1000	*******	1000
7.0	8183.50	6.9861	8180.61	*******	6.9850	8180.60	1002	1000	*******	1000
8.0	7171.17	7.9880	7168.64	*******	7.9869	7168.63	1002	1000	*******	1000
9.0	6383.02	8.9895	6380.76	*******	8.9883	6380.76	1002	1000	*******	1000
10.0	5752.30	9.9907	5750.27	*******	9.9895	5750.26	1001	1000	*******	1000
12.0	4806.54	11.9925	4804.84	*******	11.9913	4804.84	1001	1000	*******	1000
14.0	4131.97	13.9937	4130.51	*******	13.9926	4130.51	1001	1000	*******	1000
16.0	3627.21	15.9947	3625.93	*******	15.9935	3625.93	1001	1000	*******	1000
18.0	3235.80	17.9954	3234.66	*******	17.9943	3234.66	1001	1000	*******	1000
20.0	2923.82	19.9960	2922.79	*******	19.9949	2922.79	1001	1000	*******	1000
25.0	2366.54	24.9971	2365.71	*******	24.9960	2365.70	1001	1000	*******	1000
30.0	2000.43	29.9978	1999.72	*******	29.9968	1999.72	1000	1000	*******	1000
35.0	1743.90	34.9983	1743.29	*******	34.9973	1743.28	1000	1000	*******	1000
40.0	1556.17	39.9987	1555.62	*******	39.9978	1555.62	1000	1000	*******	1000
45.0	1414.65	44.9990	1414.15	*******	44.9981	1414.15	1000	1000	*******	1000
50.0	1305.83	49.9992	1305.37	*******	49.9984	1305.37	1000	1000	*******	1000
60.0	1155.09	59.9995	1154.68	*******	59.9989	1154.68	1000	1000	*******	1000
70.0	1064.55	69.9997	1064.18	*******	69.9993	1064.17	1000	1000	*******	1000
80.0	1015.78	79.9999	1015.42	*******	79.9997	1015.42	1000	1000	*******	1000
90.0	1000.35	90.0000	1000.00	*******	90.0000	1000.00	1000	1000	*******	1000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

COMPARISON OF GRADIENT (GMD), WHITE SANDS (CYBER) AND SPHERICAL SLAB (VARIAN) CORRECTION METHODS

BASED ON MEASURED VALUES CONTAINED IN JSC INTERNAL NOTE 75-FM-60 'REFRACTION CORRECTIONS FOR AN EXPONENTIAL ATMOSPHERE'

SEA LEVEL MODULUS OF REFRACTION: .0003860 SCALE HEIGHT: 5610.93 TARGET ALTITUDE: 2000 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	208511.69	-.3872	208438.26	*******	-.3852	208441.17	3407	1997	*******	2004
.5	133433.31	.2611	133388.53	*******	.2474	133384.00	2560	2002	*******	1970
1.0	91777.42	.8382	91747.16	*******	.8393	91745.81	2262	2002	*******	2003
1.5	68029.26	1.3810	68006.99	*******	1.3843	68006.69	2143	2001	*******	2005
2.0	53435.22	1.9070	53417.78	*******	1.9091	53417.79	2088	2001	*******	2003
2.5	43776.40	2.4242	43762.14	*******	2.4247	43762.21	2059	2001	*******	2001
3.0	36983.05	2.9362	36971.02	*******	2.9356	36971.08	2042	2001	*******	2000
3.5	31974.82	3.4450	31964.42	*******	3.4441	31964.46	2032	2001	*******	2000
4.0	28140.97	3.9518	28131.82	*******	3.9515	28131.84	2025	2000	*******	2000
4.5	25117.57	4.4571	25109.41	*******	4.4584	25109.41	2020	2000	*******	2001
5.0	22675.22	4.9615	22667.85	*******	4.9615	22667.84	2016	2000	*******	2000
6.0	18976.96	5.9680	18970.80	*******	5.9676	18970.78	2012	2000	*******	2000
7.0	16313.56	6.9727	16308.26	*******	6.9720	16308.24	2009	2000	*******	2000
8.0	14306.35	7.9762	14301.70	*******	7.9754	14301.69	2007	2000	*******	2000
9.0	12740.69	8.9790	12736.55	*******	8.9781	12736.54	2005	2000	*******	2000
10.0	11486.07	9.9813	11482.34	*******	9.9803	11482.33	2005	2000	*******	2000
12.0	9602.32	11.9846	9599.20	*******	11.9836	9599.20	2003	2000	*******	2000
14.0	8257.14	13.9870	8254.46	*******	13.9860	8254.46	2003	2000	*******	2000
16.0	7249.85	15.9888	7247.50	*******	15.9878	7247.49	2002	2000	*******	2000
18.0	6468.39	17.9903	6466.29	*******	17.9892	6466.29	2002	2000	*******	2000
20.0	5845.29	19.9914	5843.39	*******	19.9904	5843.39	2002	2000	*******	2000
25.0	4731.86	24.9935	4730.32	*******	24.9925	4730.32	2001	2000	*******	2000
30.0	4000.15	29.9949	3998.85	*******	29.9939	3998.85	2001	2000	*******	2000
35.0	3487.35	34.9959	3486.22	*******	34.9950	3486.22	2001	2000	*******	2000
40.0	3112.04	39.9967	3111.03	*******	39.9958	3111.03	2001	2000	*******	2000
45.0	2829.08	44.9973	2828.16	*******	44.9965	2828.16	2001	2000	*******	2000
50.0	2611.49	49.9978	2610.64	*******	49.9971	2610.64	2001	2000	*******	2000
60.0	2310.08	59.9985	2309.33	*******	59.9980	2309.33	2001	2000	*******	2000
70.0	2129.02	69.9991	2128.33	*******	69.9987	2128.33	2001	2000	*******	2000
80.0	2031.51	79.9996	2030.85	*******	79.9994	2030.85	2001	2000	*******	2000
90.0	2000.65	90.0000	2000.00	*******	90.0000	2000.00	2001	2000	*******	2000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

COMPARISON OF GRADIENT (GMD), WHITE SANDS (CYBER) AND SPHERICAL SLAB (VARIAN) CORRECTION METHODS

BASED ON MEASURED VALUES CONTAINED IN JSC INTERNAL NOTE 75-FM-60 'REFRACTION CORRECTIONS FOR AN EXPONENTIAL ATMOSPHERE'

SEA LEVEL MODULUS OF REFRACTION: .0003860 SCALE HEIGHT: 5610.93 TARGET ALTITUDE: 5000 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	321912.52	-.5568	321812.10	*******	-.4899	321831.83	8118	4989	*******	5365
.5	240923.86	.1089	240855.00	*******	.0924	240851.95	6649	5003	*******	4934
1.0	185873.89	.7085	185823.12	*******	.7068	185822.02	5950	5003	*******	4997
1.5	148057.21	1.2723	148017.75	*******	1.2767	148017.74	5592	5002	*******	5013
2.0	121482.77	1.8154	121450.84	*******	1.8193	121451.18	5394	5002	*******	5010
2.5	102254.56	2.3458	102227.91	*******	2.3474	102228.26	5278	5002	*******	5004
3.0	87905.49	2.8682	87882.70	*******	2.8679	87882.95	5204	5001	*******	5001
3.5	76898.74	3.3851	76878.87	*******	3.3845	76879.01	5156	5001	*******	5000
4.0	68234.87	3.8984	68217.28	*******	3.8991	68217.34	5123	5001	*******	5002
4.5	61264.47	4.4091	61248.71	*******	4.4130	61248.70	5099	5001	*******	5005
5.0	55550.01	4.9178	55535.74	*******	4.9214	55535.68	5081	5001	*******	5004
6.0	46765.66	5.9311	46753.67	*******	5.9329	46753.57	5058	5001	*******	5002
7.0	40350.59	6.9409	40340.25	*******	6.9417	40340.17	5043	5001	*******	5001
8.0	35472.45	7.9483	35463.37	*******	7.9485	35463.30	5033	5000	*******	5001
9.0	31644.13	8.9541	31636.03	*******	8.9540	31635.98	5027	5000	*******	5000
10.0	28563.07	9.9588	28555.76	*******	9.9585	28555.73	5022	5000	*******	5000
12.0	23917.22	11.9659	23911.11	*******	11.9653	23911.08	5016	5000	*******	5000
14.0	20586.88	13.9710	20581.62	*******	13.9703	20581.60	5012	5000	*******	5000
16.0	18087.07	15.9749	18082.45	*******	15.9741	18082.44	5009	5000	*******	5000
18.0	16144.58	17.9779	16140.46	*******	17.9771	16140.45	5007	5000	*******	5000
20.0	14594.01	19.9803	14590.28	*******	19.9796	14590.28	5006	5000	*******	5000
25.0	11819.83	24.9848	11816.81	*******	24.9840	11816.81	5004	5000	*******	5000
30.0	9994.72	29.9878	9992.17	*******	29.9871	9992.17	5003	5000	*******	5000
35.0	8714.82	34.9901	8712.59	*******	34.9893	8712.59	5003	5000	*******	5000
40.0	7777.72	39.9918	7775.73	*******	39.9911	7775.73	5002	5000	*******	5000
45.0	7071.03	44.9932	7069.23	*******	44.9925	7069.22	5002	5000	*******	5000
50.0	6527.50	49.9943	6525.83	*******	49.9937	6525.83	5002	5000	*******	5000
60.0	5774.47	59.9961	5773.00	*******	59.9957	5773.00	5001	5000	*******	5000
70.0	5322.06	69.9976	5320.70	*******	69.9973	5320.70	5001	5000	*******	5000
80.0	5078.39	79.9988	5077.10	*******	79.9987	5077.09	5001	5000	*******	5000
90.0	5001.28	90.0000	5000.00	*******	90.0000	5000.00	5001	5000	*******	5000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

COMPARISON OF GRADIENT (GMD), WHITE SANDS (CYBER) AND SPHERICAL SLAB (VARIAN) CORRECTION METHODS

BASED ON MEASURED VALUES CONTAINED IN JSC INTERNAL NOTE 75-FM-60 'REFRACTION CORRECTIONS FOR AN EXPONENTIAL ATMOSPHERE'

SEA LEVEL MODULUS OF REFRACTION: .0003860 SCALE HEIGHT: 5610.93 TARGET ALTITUDE: 10000 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	442467.95	-.6935	442351.10	*******	-.5816	442383.70	15329	9977	*******	10842
.5	358881.42	-.0129	358798.18	*******	-.0020	358799.17	13215	10004	*******	10072
1.0	296788.75	.6003	296725.16	*******	.6091	296725.85	12073	10003	*******	10049
1.5	249668.60	1.1767	249617.75	*******	1.1857	249618.70	11412	10003	*******	10042
2.0	213355.14	1.7309	213313.10	*******	1.7374	213314.03	11005	10002	*******	10027
2.5	184983.95	2.2709	184948.31	*******	2.2738	184949.01	10742	10002	*******	10012
3.0	162487.42	2.8013	162456.59	*******	2.8015	162457.02	10565	10001	*******	10001
3.5	144410.59	3.3251	144383.49	*******	3.3246	144383.68	10442	10001	*******	10000
4.0	129662.00	3.8441	129637.86	*******	3.8457	129637.87	10354	10001	*******	10004
4.5	117463.01	4.3596	117441.27	*******	4.3660	117441.17	10289	10001	*******	10014
5.0	107243.77	4.8724	107224.01	*******	4.8800	107223.83	10240	10001	*******	10015
6.0	91164.64	5.8924	91147.95	*******	5.8967	91147.72	10173	10001	*******	10008
7.0	79155.21	6.9071	79140.78	*******	6.9097	79140.57	10130	10001	*******	10004
8.0	69884.07	7.9184	69871.36	*******	7.9200	69871.20	10101	10001	*******	10002
9.0	62530.98	8.9274	62519.63	*******	8.9283	62519.51	10081	10001	*******	10002
10.0	56567.83	9.9346	56557.58	*******	9.9352	56557.49	10066	10000	*******	10001
12.0	47506.98	11.9457	47498.39	*******	11.9457	47498.33	10046	10000	*******	10000
14.0	40966.29	13.9536	40958.89	*******	13.9534	40958.86	10034	10000	*******	10000
16.0	36034.69	15.9597	36028.38	*******	15.9594	36028.36	10026	10000	*******	10000
18.0	32191.44	17.9645	32185.63	*******	17.9640	32185.62	10021	10000	*******	10000
20.0	29116.97	19.9683	29111.72	*******	19.9678	29111.71	10017	10000	*******	10000
25.0	23603.76	24.9753	23599.51	*******	24.9748	23599.50	10011	10000	*******	10000
30.0	19969.07	29.9802	19965.47	*******	29.9796	19965.47	10008	10000	*******	10000
35.0	17417.12	34.9837	17413.98	*******	34.9832	17413.98	10006	10000	*******	10000
40.0	15547.30	39.9864	15544.50	*******	39.9860	15544.50	10005	10000	*******	10000
45.0	14136.52	44.9887	14133.97	*******	44.9882	14133.97	10004	10000	*******	10000
50.0	13051.12	49.9905	13048.77	*******	49.9901	13048.77	10003	10000	*******	10000
60.0	11546.86	59.9935	11544.78	*******	59.9932	11544.78	10002	10000	*******	10000
70.0	10642.88	69.9959	10640.96	*******	69.9957	10640.96	10002	10000	*******	10000
80.0	10155.91	79.9980	10154.08	*******	79.9979	10154.08	10002	10000	*******	10000
90.0	10001.80	90.0000	10000.00	*******	90.0000	10000.00	10002	10000	*******	10000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

COMPARISON OF GRADIENT (GMD), WHITE SANDS (CYBER) AND SPHERICAL SLAB (VARIAN) CORRECTION METHODS

BASED ON MEASURED VALUES CONTAINED IN JSC INTERNAL NOTE 75-FM-60 'REFRACTION CORRECTIONS FOR AN EXPONENTIAL ATMOSPHERE'

SEA LEVEL MODULUS OF REFRACTION: .0003860 SCALE HEIGHT: 5610.93 TARGET ALTITUDE: 20000 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	603994.40	-.8155	603868.60	*******	-.6991	603909.05	28534	19961	*******	21187
.5	518812.71	-.1169	518722.43	*******	-.1202	518728.25	25577	20003	*******	19974
1.0	452108.11	.5090	452038.47	*******	.5088	452039.54	23869	20003	*******	20002
1.5	398145.30	1.0955	398089.06	*******	1.0983	398090.25	22808	20003	*******	20023
2.0	353657.15	1.6581	353610.24	*******	1.6601	353611.30	22109	20002	*******	20015
2.5	316568.79	2.2052	316528.71	*******	2.2044	316529.44	21628	20002	*******	19998
3.0	285374.36	2.7417	285339.48	*******	2.7387	285339.84	21284	20000	*******	19985
3.5	258989.79	3.2707	258958.97	*******	3.2677	258959.03	21034	20000	*******	19987
4.0	236497.73	3.7943	236470.16	*******	3.7945	236470.00	20848	20000	*******	20001
4.5	217192.73	4.3137	217167.82	*******	4.3207	217167.53	20705	20000	*******	20027
5.0	200511.07	4.8299	200488.37	*******	4.8395	200488.00	20594	20000	*******	20034
6.0	173298.67	5.8555	173279.42	*******	5.8612	173279.00	20436	20001	*******	20018
7.0	152201.00	6.8747	152184.30	*******	6.8783	152183.95	20332	20001	*******	20010
8.0	135471.75	7.8896	135457.02	*******	7.8919	135456.75	20261	20001	*******	20006
9.0	121940.42	8.9014	121927.25	*******	8.9030	121927.04	20209	20000	*******	20004
10.0	110804.33	9.9111	110792.42	*******	9.9121	110792.26	20172	20000	*******	20002
12.0	93623.47	11.9258	93613.47	*******	11.9263	93613.38	20121	20000	*******	20001
14.0	81043.11	13.9366	81034.49	*******	13.9367	81034.43	20089	20000	*******	20001
16.0	71469.62	15.9447	71462.04	*******	15.9447	71462.00	20069	20000	*******	20000
18.0	63960.69	17.9512	63953.92	*******	17.9511	63953.89	20054	20000	*******	20000
20.0	57926.86	19.9564	57920.73	*******	19.9562	57920.71	20044	20000	*******	20000
25.0	47053.05	24.9660	47048.08	*******	24.9657	47048.07	20028	20000	*******	20000
30.0	39851.40	29.9725	39847.20	*******	29.9723	39847.19	20019	20000	*******	20000
35.0	34781.81	34.9774	34778.15	*******	34.9771	34778.14	20013	20000	*******	20000
40.0	31061.24	39.9811	31057.97	*******	39.9809	31057.97	20010	20000	*******	20000
45.0	28251.04	44.9842	28248.07	*******	44.9839	28248.06	20008	20000	*******	20000
50.0	26087.34	49.9868	26084.59	*******	49.9865	26084.59	20006	20000	*******	20000
60.0	23086.57	59.9909	23084.14	*******	59.9907	23084.14	20004	20000	*******	20000
70.0	21282.18	69.9943	21279.94	*******	69.9942	21279.94	20003	20000	*******	20000
80.0	20309.87	79.9972	20307.73	*******	79.9972	20307.73	20002	20000	*******	20000
90.0	20002.11	90.0000	20000.01	*******	90.0000	20000.01	20002	20000	*******	20000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

COMPARISON OF GRADIENT (GMD), WHITE SANDS (CYBER) AND SPHERICAL SLAB (VARIAN) CORRECTION METHODS

BASED ON MEASURED VALUES CONTAINED IN JSC INTERNAL NOTE 75-FM-60 'REFRACTION CORRECTIONS FOR AN EXPONENTIAL ATMOSPHERE'

SEA LEVEL MODULUS OF REFRACTION: .0003860 SCALE HEIGHT: 5610.93 TARGET ALTITUDE: 50000 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	910793.99	-.9365	910663.45	*******	-.8368	910708.26	64702	49932	*******	51510
.5	824342.11	-.2127	824249.15	*******	-.2736	824257.31	60181	50003	*******	49135
1.0	753907.56	.4295	753836.12	*******	.3913	753835.35	57455	50003	*******	49504
1.5	694042.58	1.0274	693984.98	*******	1.0051	693985.21	55686	50003	*******	49735
2.0	641883.19	1.5985	641835.18	*******	1.5831	641835.69	54468	50003	*******	49831
2.5	595807.39	2.1522	595766.38	*******	2.1386	595766.76	53592	50002	*******	49862
3.0	554742.22	2.6941	554706.52	*******	2.6812	554706.63	52938	49998	*******	49875
3.5	518008.85	3.2274	517977.30	*******	3.2170	517977.15	52443	49999	*******	49905
4.0	484997.01	3.7546	484968.78	*******	3.7498	484968.45	52059	49999	*******	49959
4.5	455242.85	4.2772	455217.33	*******	4.2817	455216.90	51754	49999	*******	50035
5.0	428356.61	4.7961	428333.34	*******	4.8047	428332.85	51510	50000	*******	50063
6.0	381895.22	5.8261	381875.47	*******	5.8311	381874.96	51147	50000	*******	50033
7.0	343427.70	6.8487	343410.56	*******	6.8519	343410.14	50896	50000	*******	50019
8.0	311282.20	7.8663	311267.08	*******	7.8684	311266.75	50716	50000	*******	50011
9.0	284171.01	8.8804	284157.48	*******	8.8819	284157.23	50584	50000	*******	50007
10.0	261099.36	9.8920	261087.12	*******	9.8930	261086.94	50484	50000	*******	50005
12.0	224159.63	11.9097	224149.35	*******	11.9102	224149.24	50346	50000	*******	50002
14.0	196100.68	13.9226	196091.82	*******	13.9229	196091.75	50258	50000	*******	50001
16.0	174203.28	15.9325	174195.48	*******	15.9326	174195.43	50198	50000	*******	50001
18.0	156717.90	17.9403	156710.93	*******	17.9403	156710.90	50157	50000	*******	50000
20.0	142482.17	19.9466	142475.87	*******	19.9466	142475.84	50126	50000	*******	50000
25.0	116446.31	24.9583	116441.20	*******	24.9582	116441.19	50079	50000	*******	50000
30.0	98962.21	29.9663	98957.89	*******	29.9661	98957.88	50052	50000	*******	50000
35.0	86554.25	34.9722	86550.48	*******	34.9721	86550.48	50036	50000	*******	50000
40.0	77401.43	39.9768	77398.07	*******	39.9767	77398.06	50026	50000	*******	50000
45.0	70464.56	44.9805	70461.50	*******	44.9804	70461.50	50019	50000	*******	50000
50.0	65110.90	49.9837	65108.08	*******	49.9836	65108.07	50014	50000	*******	50000
60.0	57669.38	59.9888	57666.88	*******	59.9887	57666.88	50008	50000	*******	50000
70.0	53186.20	69.9929	53183.90	*******	69.9929	53183.90	50004	50000	*******	50000
80.0	50767.93	79.9966	50765.73	*******	79.9965	50765.73	50003	50000	*******	50000
90.0	50002.17	90.0000	50000.01	*******	90.0000	50000.00	50002	50000	*******	50000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

COMPARISON OF GRADIENT (GMD), WHITE SANDS (CYBER) AND SPHERICAL SLAB (VARIAN) CORRECTION METHODS

BASED ON MEASURED VALUES CONTAINED IN JSC INTERNAL NOTE 75-FM-60 'REFRACTION CORRECTIONS FOR AN EXPONENTIAL ATMOSPHERE'

SEA LEVEL MODULUS OF REFRACTION: .0003860 SCALE HEIGHT: 5610.93 TARGET ALTITUDE: 100000 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	1250390.50	-1.0016	1250257.80	*******	-.9121	1250304.58	121409	99901	*******	101832
.5	1163337.45	-.2605	1163243.51	*******	-.3544	1163252.57	115204	100003	*******	98127
1.0	1091120.67	.3923	1091048.71	*******	.3330	1091046.76	111400	100004	*******	98891
1.5	1028349.90	.9972	1028292.01	*******	.9614	1028291.64	108890	100003	*******	99370
2.0	972251.85	1.5733	972203.66	*******	1.5487	972203.85	107134	100003	*******	99592
2.5	921320.18	2.1306	921279.05	*******	2.1104	921279.25	105851	100002	*******	99684
3.0	874609.93	2.6752	874574.15	*******	2.6575	874574.15	104877	99996	*******	99731
3.5	831588.85	3.2107	831557.24	*******	3.1966	831557.02	104129	99997	*******	99797
4.0	791780.91	3.7396	791752.63	*******	3.7323	791752.25	103537	99998	*******	99899
4.5	754853.54	4.2635	754827.99	*******	4.2668	754827.52	103061	99998	*******	100040
5.0	720536.96	4.7836	720513.67	*******	4.7915	720513.15	102672	99999	*******	100096
6.0	658852.88	5.8154	658833.12	*******	5.8200	658832.59	102081	99999	*******	100051
7.0	605213.48	6.8394	605196.33	*******	6.8423	605195.89	101661	99999	*******	100029
8.0	558394.60	7.8581	558379.47	*******	7.8600	558379.13	101351	100000	*******	100017
9.0	517376.01	8.8730	517362.47	*******	8.8743	517362.22	101118	100000	*******	100011
10.0	481299.06	9.8853	481286.82	*******	9.8862	481286.63	100938	100000	*******	100007
12.0	421189.36	11.9040	421179.08	*******	11.9045	421178.96	100682	100000	*******	100003
14.0	373544.54	13.9177	373535.67	*******	13.9180	373535.60	100515	100000	*******	100002
16.0	335165.07	15.9282	335157.27	*******	15.9284	335157.22	100400	100000	*******	100001
18.0	303778.21	17.9365	303771.24	*******	17.9366	303771.21	100318	100000	*******	100000
20.0	277753.64	19.9432	277747.34	*******	19.9432	277747.31	100257	100000	*******	100000
25.0	229124.13	24.9556	229119.02	*******	24.9555	229119.01	100161	100000	*******	100000
30.0	195776.10	29.9641	195771.78	*******	29.9640	195771.77	100107	100000	*******	100000
35.0	171808.22	34.9703	171804.45	*******	34.9703	171804.45	100074	100000	*******	100000
40.0	153983.17	39.9752	153979.81	*******	39.9752	153979.80	100052	100000	*******	100000
45.0	140398.84	44.9792	140395.78	*******	44.9792	140395.78	100038	100000	*******	100000
50.0	129874.11	49.9826	129871.29	*******	49.9825	129871.28	100027	100000	*******	100000
60.0	115190.67	59.9880	115188.17	*******	59.9880	115188.17	100014	100000	*******	100000
70.0	106316.53	69.9924	106314.23	*******	69.9924	106314.23	100007	100000	*******	100000
80.0	101521.64	79.9963	101519.44	*******	79.9963	101519.44	100003	100000	*******	100000
90.0	100002.17	90.0000	100000.01	*******	90.0000	100000.00	100002	100000	*******	100000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

APPENDIX D

TABULATED REFRACTION COMPARISON DATA FOR EDWARDS EHA-75 HOT DAY CONDITIONS

TABLE D-I

WEATHER DATA FOR EDWARDS EHA-75 HOT DAY

ALTITUDE (FT)	TEMPERATURE (DEG C)	DEW POINT (DEG C)	PRESSURE (MB)	N X 10E6
2316	43.69995	8.84998	929.00000	270.30353
3000	38.58756	7.11333	903.25562	264.14508
4000	36.85410	6.14978	891.03394	260.40588
5000	33.24156	3.34049	857.79834	249.10526
6000	29.12725	.12280	819.52612	236.17365
7000	26.56799	-1.93021	794.60022	227.98520
8000	24.10647	-4.03682	768.15747	219.90646
9000	21.49864	-6.32584	739.38721	211.39047
10000	19.05116	-8.47149	713.05518	203.66263
11000	16.59399	-10.61668	688.07678	196.55545
12000	14.05948	-12.81905	663.23145	189.72156
13000	11.61666	-14.90845	639.75146	183.34998
14000	9.20186	-16.92825	617.23413	177.32986
15000	6.64556	-19.08471	594.35840	171.38351
16000	4.16272	-21.27731	572.38318	165.70724
17000	1.87212	-23.51741	551.87170	160.34540
18000	-.46410	-26.06773	531.02637	154.89380
19000	-2.75558	-28.60963	510.69012	149.60373
20000	-4.89093	-30.78820	491.85645	144.75958
21000	-7.06930	-32.70390	473.03528	140.02933
22000	-9.26616	-34.49268	454.41113	135.40790
23000	-11.34800	-36.20806	437.01611	131.08182
24000	-13.44421	-38.00616	420.13660	126.84921
25000	-15.62985	-39.89327	403.19788	122.58925
26000	-17.74000	-41.72385	387.11890	118.53600
27000	-19.75973	-43.48828	371.99591	114.70740
28000	-21.89243	-45.36777	356.70337	110.80807
29000	-24.00026	-47.22755	341.96582	107.03584
30000	-25.98938	-48.97205	328.30975	103.53395
31000	-28.10549	-50.81854	314.59778	99.99405
32000	-30.26072	-52.69841	301.19305	96.51865
33000	-32.30277	-54.48528	288.76862	93.29465
34000	-34.44572	-56.34369	276.54724	90.10873
35000	-36.68972	-58.24686	264.43378	86.93344
36000	-38.83938	-60.00636	253.05801	83.94058
37000	-40.94783	-61.59187	242.22083	81.06636
38000	-43.17965	-63.13728	231.34473	78.14810
39000	-45.36091	-64.62108	220.97690	75.34836
40000	-47.42838	-66.07417	211.32605	72.72676
41000	-49.62975	-67.62959	201.63461	70.05484
42000	-51.84161	-69.18915	192.26611	67.45100
43000	-53.93611	-70.65814	183.60962	65.04021
44000	-56.14576	-72.20313	175.02695	62.61802
45000	-58.38364	-73.77621	166.62195	60.21470
46000	-60.44167	-75.24471	158.81183	57.96035
47000	-62.46535	-76.62076	151.26779	55.74521
48000	-64.63737	-77.89751	143.78864	53.52798
49000	-66.91588	-78.96187	136.73184	51.45824
50000	-69.38409	-79.65543	130.10373	49.55390

TABLE D-I -- Continued

WEATHER DATA FOR EDWARDS EHA-75 HOT DAY

ALTITUDE (FT)	TEMPERATURE (DEG C)	DEW POINT (DEG C)	PRESSURE (MB)	N X 10E6
51000	-71.93837	-79.95189	123.48726	47.61012
52000	-73.92885	-80.07860	117.17973	45.63460
53000	-74.58440	-80.21500	111.38791	43.56802
54000	-73.34724	-80.22905	105.72054	41.12403
55000	-71.31264	-80.17506	100.29747	38.60095
56000	-69.71280	-80.15002	95.32890	36.36906
57000	-68.36600	-80.15002	90.59485	34.33443
58000	-66.95903	-80.15002	86.05518	32.40004
59000	-65.57408	-80.15002	81.84933	30.60943
60000	-64.15100	-80.15002	77.90450	28.93344
61000	-62.67793	-80.15002	74.08270	27.32929
62000	-61.36696	-80.15002	70.49979	25.84626
63000	-60.41143	-80.15002	67.18153	24.50804
64000	-59.77395	-80.15002	63.94312	23.25805
65000	-59.26440	-80.15002	60.86837	22.09315
66000	-58.69947	-80.15002	58.03733	21.00944
67000	-58.05980	-80.15002	55.28382	19.95426
68000	-57.40619	-80.15002	52.63624	18.94324
69000	-56.78934	-80.15002	50.19029	18.01028
70000	-56.16160	-80.15002	47.85101	17.12111
71000	-55.50677	-80.15002	45.57531	16.25982
72000	-54.87612	-80.15002	43.44771	15.45611
73000	-54.26505	-80.15002	41.45888	14.70639
74000	-53.61657	-80.15002	39.50738	13.97437
75000	-52.97717	-80.15002	37.66196	13.28384
76000	-52.37175	-80.15002	35.96156	12.64812
77000	-51.72646	-80.15002	34.29820	12.02902
78000	-51.07536	-80.15002	32.70680	11.43848
79000	-50.46436	-80.15002	31.23968	10.89460
80000	-49.82896	-80.15002	29.81631	10.36910
81000	-49.17453	-80.15002	28.43674	9.86171
82000	-48.55239	-80.15002	27.15546	9.39114
83000	-47.93436	-80.15002	25.94243	8.94686
84000	-47.28407	-80.15002	24.75444	8.51371
85000	-46.65055	-80.15002	23.63672	8.10699
86000	-46.04258	-80.15002	22.59821	7.72960
87000	-45.39286	-80.15002	21.57514	7.35950
88000	-44.74556	-80.15002	20.60023	7.00774
89000	-44.13775	-80.15002	19.70158	6.68383
90000	-43.49626	-80.15002	18.82100	6.36783
91000	-42.84356	-80.15002	17.97160	6.06404
92000	-42.22903	-80.15002	17.18723	5.78379
93000	-41.60152	-80.15002	16.43345	5.51540
94000	-40.95004	-80.15002	15.69908	5.25495
95000	-40.32507	-80.15002	15.01326	5.01210
96000	-39.71589	-80.15002	14.37071	4.78499
97000	-39.06644	-80.15002	13.73852	4.56246
98000	-38.42149	-80.15002	13.13915	4.35189
99000	-37.80067	-80.15002	12.58263	4.15653
100000	-37.13890	-80.15002	12.03220	3.96417

COMPARISON OF GRADIENT (GMD), WHITE SANDS (CYBER) AND SPHERICAL SLAB (VARIAN) CORRECTION METHODS

BASED ON RESULTS OF GRADIENT REFRACTION SOLUTION FOR THE SAME MEASURED EL ANGLES AS USED IN JSC INTERNAL NOTE 75-FM-60

WEATHER DATA FOR EDWARDS EHA-75 HOT DAY SEA LEVEL INDEX OF REFRACTION: .0002939 SCALE HEIGHT: 7284.10 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	130488.61	-.1467	130451.73	-.1577	-.1490	130444.37	1335	1000	976	994
.5	75757.79	.4164	75736.73	.4126	.4134	75735.50	1111	1000	995	996
1.0	49121.62	.9463	49108.03	.9441	.9466	49107.77	1046	1000	998	1000
1.5	35374.34	1.4616	35364.57	1.4599	1.4623	35364.55	1024	1000	999	1000
2.0	27384.03	1.9705	27376.47	1.9690	1.9707	27376.51	1014	1000	1000	1000
2.5	22255.74	2.4761	22249.60	2.4749	2.4759	22249.65	1010	1000	1000	1000
3.0	18713.66	2.9801	18708.49	2.9789	2.9795	18708.54	1007	1000	1000	1000
3.5	16130.52	3.4829	16126.07	3.4818	3.4822	16126.11	1005	1000	1000	1000
4.0	14167.60	3.9851	14163.70	3.9841	3.9846	14163.72	1004	1000	1000	1000
4.5	12627.46	4.4868	12623.98	4.4858	4.4868	12624.00	1003	1000	1000	1000
5.0	11387.79	4.9882	11384.65	4.9872	4.9877	11384.67	1003	1000	1000	1000
6.0	9517.44	5.9903	9514.82	5.9893	5.9897	9514.83	1002	1000	1000	1000
7.0	8175.00	6.9918	8172.75	6.9908	6.9911	8172.76	1001	1000	1000	1000
8.0	7165.11	7.9929	7163.14	7.9920	7.9922	7163.15	1001	1000	1000	1000
9.0	6378.61	8.9937	6376.85	8.9929	8.9931	6376.85	1001	1000	1000	1000
10.0	5748.92	9.9944	5747.34	9.9936	9.9938	5747.34	1001	1000	1000	1000
12.0	4804.48	11.9955	4803.16	11.9947	11.9948	4803.16	1001	1000	1000	1000
14.0	4130.56	13.9963	4129.42	13.9955	13.9956	4129.42	1001	1000	1000	1000
16.0	3626.11	15.9968	3625.12	15.9961	15.9962	3625.12	1000	1000	1000	1000
18.0	3234.88	17.9973	3233.99	17.9965	17.9966	3233.99	1000	1000	1000	1000
20.0	2923.14	19.9976	2922.34	19.9969	19.9970	2922.34	1000	1000	1000	1000
25.0	2366.05	24.9983	2365.40	24.9976	24.9976	2365.40	1000	1000	1000	1000
30.0	1999.99	29.9987	1999.43	29.9980	29.9981	1999.44	1000	1000	1000	1000
35.0	1743.58	34.9990	1743.10	34.9984	34.9984	1743.10	1000	1000	1000	1000
40.0	1555.95	39.9992	1555.52	39.9987	39.9987	1555.52	1000	1000	1000	1000
45.0	1414.49	44.9994	1414.10	44.9989	44.9989	1414.10	1000	1000	1000	1000
50.0	1305.54	49.9995	1305.18	49.9991	49.9991	1305.18	1000	1000	1000	1000
60.0	1154.86	59.9997	1154.55	59.9993	59.9994	1154.55	1000	1000	1000	1000
70.0	1064.36	69.9998	1064.07	69.9996	69.9996	1064.07	1000	1000	1000	1000
80.0	1015.61	79.9999	1015.34	79.9998	79.9998	1015.34	1000	1000	1000	1000
90.0	1000.19	90.0000	999.92	90.0000	90.0000	999.92	1000	1000	1000	1000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

COMPARISON OF GRADIENT (GMD), WHITE SANDS (CYBER) AND SPHERICAL SLAB (VARIAN) CORRECTION METHODS

BASED ON RESULTS OF GRADIENT REFRACTION SOLUTION FOR THE SAME MEASURED EL ANGLES AS USED IN JSC INTERNAL NOTE 75-FM-60

WEATHER DATA FOR EDWARDS EHA-75 HOT DAY SEA LEVEL INDEX OF REFRACTION: .0002939 SCALE HEIGHT: 7284.10 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	184047.44	-.2035	183996.95	-.2224	-.2051	183993.28	2655	2000	1941	1995
.5	124157.76	.3658	124124.54	.3608	.3604	124123.04	2291	2000	1990	1988
1.0	88093.29	.9058	88069.95	.9041	.9077	88069.78	2145	2000	1998	2003
1.5	66367.38	1.4295	66349.87	1.4287	1.4323	66350.10	2082	2000	2000	2003
2.0	52583.71	1.9444	52569.87	1.9439	1.9463	52570.18	2052	2000	2000	2002
2.5	43292.05	2.4544	43280.67	2.4540	2.4552	43280.97	2035	2000	2000	2001
3.0	36685.57	2.9615	36675.93	2.9611	2.9616	36676.19	2025	2000	2000	2000
3.5	31779.22	3.4668	31770.87	3.4663	3.4666	31771.09	2019	2000	2000	2000
4.0	28005.88	3.9708	27998.53	3.9704	3.9710	27998.71	2015	2000	2000	2000
4.5	25020.29	4.4740	25013.72	4.4736	4.4750	25013.88	2012	2000	2000	2000
5.0	22602.95	4.9766	22597.02	4.9762	4.9769	22597.15	2010	2000	2000	2000
6.0	18933.71	5.9806	18928.74	5.9801	5.9805	18928.84	2007	2000	2000	2000
7.0	16285.56	6.9834	16281.29	6.9829	6.9832	16281.37	2005	2000	2000	2000
8.0	14287.26	7.9856	14283.51	7.9850	7.9852	14283.58	2004	2000	2000	2000
9.0	12726.84	8.9873	12723.50	8.9867	8.9868	12723.56	2003	2000	2000	2000
10.0	11475.71	9.9886	11472.70	9.9881	9.9881	11472.76	2003	2000	2000	2000
12.0	9596.12	11.9907	9593.60	11.9901	11.9901	9593.65	2002	2000	2000	2000
14.0	8253.05	13.9921	8250.88	13.9915	13.9916	8250.92	2002	2000	2000	2000
16.0	7246.88	15.9932	7244.98	15.9926	15.9927	7245.02	2001	2000	2000	2000
18.0	6466.19	17.9941	6464.50	17.9935	17.9935	6464.53	2001	2000	2000	2000
20.0	5843.58	19.9948	5842.05	19.9942	19.9942	5842.08	2001	2000	2000	2000
25.0	4730.78	24.9961	4729.54	24.9955	24.9955	4729.56	2001	2000	2000	2000
30.0	3999.40	29.9969	3998.35	29.9963	29.9963	3998.37	2001	2000	2000	2000
35.0	3486.88	34.9975	3485.97	34.9970	34.9970	3485.99	2001	2000	2000	2000
40.0	3111.60	39.9980	3110.79	39.9975	39.9975	3110.80	2001	2000	2000	2000
45.0	2828.78	44.9983	2828.04	44.9979	44.9979	2828.05	2001	2000	2000	2000
50.0	2611.12	49.9986	2610.44	49.9982	49.9982	2610.45	2000	2000	2000	2000
60.0	2309.84	59.9991	2309.24	59.9988	59.9988	2309.25	2000	2000	2000	2000
70.0	2128.86	69.9995	2128.30	69.9992	69.9992	2128.31	2001	2000	2001	2000
80.0	2031.21	79.9997	2030.68	79.9996	79.9996	2030.69	2000	2000	2000	2000
90.0	2000.37	90.0000	1999.85	90.0000	90.0000	1999.86	2000	2000	2000	2000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

COMPARISON OF GRADIENT (GMD), WHITE SANDS (CYBER) AND SPHERICAL SLAB (VARIAN) CORRECTION METHODS

BASED ON RESULTS OF GRADIENT REFRACTION SOLUTION FOR THE SAME MEASURED EL ANGLES AS USED IN JSC INTERNAL NOTE 75-FM-60

WEATHER DATA FOR EDWARDS EHA-75 HOT DAY SEA LEVEL INDEX OF REFRACTION: .0002939 SCALE HEIGHT: 7284.10 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	288718.61	-.3036	288646.65	-.3489	-.2533	288652.11	6531	5000	4775	5253
.5	224057.01	.2733	224003.69	.2625	.2760	224003.71	5888	5000	4960	5011
1.0	176990.67	.8249	176949.66	.8249	.8317	176950.51	5542	5000	5002	5021
1.5	143123.47	1.3603	143090.81	1.3637	1.3682	143092.06	5350	5000	5010	5020
2.0	118580.41	1.8852	118553.59	1.8896	1.8916	118554.88	5239	5000	5010	5013
2.5	100449.11	2.4034	100426.52	2.4077	2.4075	100427.70	5170	5000	5009	5007
3.0	86730.01	2.9169	86710.57	2.9210	2.9194	86711.60	5127	5000	5007	5004
3.5	76095.39	3.4274	76078.38	3.4312	3.4292	76079.25	5097	5000	5006	5002
4.0	67664.99	3.9356	67649.89	3.9391	3.9380	67650.63	5077	5000	5005	5003
4.5	60847.22	4.4423	60833.66	4.4454	4.4463	60834.28	5062	5000	5004	5004
5.0	55236.20	4.9477	55223.89	4.9506	4.9516	55224.43	5051	5000	5004	5004
6.0	46575.89	5.9561	46565.53	5.9585	5.9586	46565.94	5037	5000	5003	5002
7.0	40227.62	6.9623	40218.68	6.9643	6.9639	40219.02	5027	5000	5003	5001
8.0	35388.37	7.9670	35380.51	7.9687	7.9681	35380.80	5021	5000	5002	5001
9.0	31584.05	8.9707	31577.03	8.9722	8.9715	31577.29	5017	5000	5002	5000
10.0	28518.66	9.9737	28512.33	9.9750	9.9742	28512.57	5014	5000	5002	5000
12.0	23891.02	11.9782	23885.72	11.9792	11.9785	23885.93	5010	5000	5002	5000
14.0	20570.08	13.9815	20565.52	13.9822	13.9816	20565.70	5008	5000	5001	5000
16.0	18075.60	15.9839	18071.59	15.9845	15.9839	18071.75	5006	5000	5001	5000
18.0	16136.38	17.9859	16132.80	17.9863	17.9858	16132.95	5005	5000	5001	5000
20.0	14587.95	19.9874	14584.72	19.9878	19.9873	14584.85	5004	5000	5001	5000
25.0	11816.62	24.9903	11814.00	24.9905	24.9900	11814.10	5003	5000	5001	5000
30.0	9992.75	29.9922	9990.53	29.9923	29.9920	9990.62	5002	5000	5001	5000
35.0	8713.49	34.9937	8711.56	34.9937	34.9934	8711.64	5002	5000	5001	5000
40.0	7776.81	39.9947	7775.09	39.9947	39.9945	7775.16	5002	5000	5001	5000
45.0	7070.36	44.9956	7068.79	44.9956	44.9953	7068.85	5001	5000	5001	5000
50.0	6526.96	49.9964	6525.51	49.9963	49.9961	6525.57	5001	5000	5001	5000
60.0	5774.11	59.9975	5772.84	59.9974	59.9973	5772.89	5001	5000	5001	5000
70.0	5321.75	69.9985	5320.57	69.9984	69.9983	5320.62	5001	5000	5001	5000
80.0	5078.16	79.9993	5077.03	79.9992	79.9992	5077.08	5001	5000	5001	5000
90.0	5001.07	90.0000	4999.96	90.0000	90.0000	5000.01	5001	5000	5001	5000

**** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

COMPARISON OF GRADIENT (GMD), WHITE SANDS (CYBER) AND SPHERICAL SLAB (VARIAN) CORRECTION METHODS

BASED ON RESULTS OF GRADIENT REFRACTION SOLUTION FOR THE SAME MEASURED EL ANGLES AS USED IN JSC INTERNAL NOTE 75-FM-60

WEATHER DATA FOR EDWARDS EHA-75 HOT DAY SEA LEVEL INDEX OF REFRACTION: .0002939 SCALE HEIGHT: 7284.10 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	403882.16	-.3936	403794.21	-.4881	-.2812	403809.47	12775	10000	9340	10792
.5	336887.45	.1896	336819.00	.1638	.2421	336823.74	11826	10000	9852	10309
1.0	283629.66	.7484	283574.61	.7471	.7840	283578.61	11246	10000	9997	10176
1.5	241435.35	1.2913	241389.91	1.2993	1.3175	241393.60	10880	10000	10036	10110
2.0	208003.66	1.8234	207965.32	1.8348	1.8426	207968.68	10642	10000	10044	10070
2.5	181382.71	2.3480	181349.76	2.3603	2.3616	181352.74	10482	10000	10041	10043
3.0	159998.09	2.8672	159969.31	2.8794	2.8768	159971.90	10372	10000	10036	10027
3.5	142629.58	3.3824	142604.11	3.3941	3.3900	142606.34	10294	10000	10031	10019
4.0	128353.98	3.8948	128331.18	3.9058	3.9025	128333.10	10237	10000	10027	10017
4.5	116479.61	4.4049	116459.00	4.4152	4.4147	116460.67	10194	10000	10023	10020
5.0	106488.82	4.9134	106470.04	4.9230	4.9236	106471.49	10162	10000	10020	10019
6.0	90695.34	5.9267	90679.41	5.9351	5.9338	90680.56	10117	10000	10015	10011
7.0	78845.85	6.9366	78832.04	6.9440	6.9419	78833.01	10088	10000	10012	10007
8.0	69670.33	7.9443	69658.15	7.9508	7.9484	69659.00	10069	10000	10010	10005
9.0	62377.59	8.9503	62366.70	8.9562	8.9537	62367.48	10055	10000	10008	10004
10.0	56454.33	9.9553	56444.48	9.9606	9.9580	56445.20	10045	10000	10007	10003
12.0	47439.94	11.9628	47431.68	11.9672	11.9648	47432.29	10032	10000	10005	10002
14.0	40923.65	13.9682	40916.53	13.9719	13.9698	40917.07	10024	10000	10004	10001
16.0	36006.14	15.9724	35999.88	15.9756	15.9736	36000.36	10018	10000	10004	10001
18.0	32171.23	17.9756	32165.64	17.9784	17.9766	32166.07	10015	10000	10003	10001
20.0	29102.22	19.9783	29097.16	19.9807	19.9791	29097.56	10012	10000	10003	10001
25.0	23596.29	24.9831	23592.19	24.9849	24.9836	23592.52	10008	10000	10002	10000
30.0	19964.85	29.9864	19961.38	29.9878	29.9867	19961.66	10006	10000	10002	10000
35.0	17414.52	34.9888	17411.50	34.9900	34.9891	17411.74	10004	10000	10002	10000
40.0	15545.61	39.9907	15542.91	39.9916	39.9909	15543.13	10004	10000	10002	10000
45.0	14135.39	44.9922	14132.94	44.9930	44.9923	14133.14	10003	10000	10002	10000
50.0	13050.38	49.9935	13048.11	49.9941	49.9936	13048.29	10003	10000	10002	10000
60.0	11546.45	59.9956	11544.45	59.9959	59.9956	11544.61	10002	10000	10002	10000
70.0	10642.67	69.9972	10640.82	69.9974	69.9972	10640.97	10002	10000	10002	10000
80.0	10155.76	79.9987	10154.00	79.9988	79.9986	10154.14	10002	10000	10002	10000
90.0	10001.69	90.0000	9999.95	90.0000	90.0000	10000.09	10002	10000	10002	10000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

COMPARISON OF GRADIENT (GMD), WHITE SANDS (CYBER) AND SPHERICAL SLAB (VARIAN) CORRECTION METHODS

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WEATHER DATA FOR EDWARDS EHA-75 HOT DAY SEA LEVEL INDEX OF REFRACTION: .0002939 SCALE HEIGHT: 7284.10 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	562319.17	-.4839	562220.73	-.6796	-.3345	562243.87	24740	20000	18093	21462
.5	493781.89	.1072	493703.71	.0442	.1943	493712.38	23380	20000	19465	20749
1.0	436172.64	.6729	436108.53	.6592	.7359	436115.49	22487	20000	19901	20478
1.5	387496.89	1.2221	387443.00	1.2291	1.2697	387449.07	21877	20000	20051	20321
2.0	346277.72	1.7600	346231.53	1.7760	1.7963	346236.90	21449	20000	20100	20219
2.5	311302.40	2.2898	311262.17	2.3096	2.3174	311266.89	21141	20000	20111	20149
3.0	281542.48	2.8138	281506.97	2.8349	2.8349	281511.08	20914	20000	20107	20104
3.5	256124.21	3.3333	256092.50	3.3544	3.3507	256096.08	20745	20000	20097	20078
4.0	234313.18	3.8494	234284.60	3.8700	3.8660	234287.72	20615	20000	20087	20068
4.5	215498.33	4.3629	215472.35	4.3827	4.3817	215475.10	20515	20000	20077	20071
5.0	199176.12	4.8744	199152.32	4.8932	4.8929	199154.77	20437	20000	20068	20064
6.0	172435.20	5.8927	172414.88	5.9096	5.9066	172416.87	20323	20000	20053	20042
7.0	151615.91	6.9066	151598.20	6.9218	6.9176	151599.92	20247	20000	20043	20029
8.0	135059.53	7.9174	135043.86	7.9312	7.9265	135045.40	20195	20000	20035	20021
9.0	121640.52	8.9261	121626.48	8.9386	8.9339	121627.89	20157	20000	20029	20016
10.0	110580.07	9.9333	110567.35	9.9447	9.9400	110568.65	20129	20000	20024	20013
12.0	93489.53	11.9442	93478.83	11.9539	11.9495	93479.97	20091	20000	20018	20009
14.0	80957.45	13.9523	80948.21	13.9605	13.9566	80949.21	20068	20000	20014	20006
16.0	71411.90	15.9584	71403.76	15.9656	15.9620	71404.66	20052	20000	20011	20005
18.0	63920.16	17.9632	63912.89	17.9696	17.9663	63913.69	20041	20000	20009	20004
20.0	57897.45	19.9671	57890.87	19.9728	19.9699	57891.61	20033	20000	20008	20003
25.0	47038.42	24.9743	47033.08	24.9788	24.9764	47033.69	20021	20000	20006	20002
30.0	39843.33	29.9793	39838.82	29.9828	29.9809	39839.33	20015	20000	20004	20001
35.0	34777.07	34.9829	34773.13	34.9858	34.9842	34773.58	20011	20000	20004	20001
40.0	31058.33	39.9858	31054.82	39.9882	39.9868	31055.22	20008	20000	20003	20001
45.0	28249.23	44.9881	28246.03	44.9901	44.9889	28246.40	20006	20000	20003	20001
50.0	26086.22	49.9900	26083.26	49.9917	49.9907	26083.60	20005	20000	20003	20000
60.0	23086.18	59.9931	23083.57	59.9943	59.9936	23083.87	20004	20000	20002	20000
70.0	21282.13	69.9957	21279.73	69.9964	69.9960	21280.00	20003	20000	20002	20000
80.0	20309.96	79.9979	20307.66	79.9982	79.9980	20307.93	20002	20000	20002	20000
90.0	20002.26	90.0000	19999.99	90.0000	90.0000	20000.25	20002	20000	20002	20000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

COMPARISON OF GRADIENT (GMD), WHITE SANDS (CYBER) AND SPHERICAL SLAB (VARIAN) CORRECTION METHODS

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WEATHER DATA FOR EDWARDS EHA-75 HOT DAY SEA LEVEL INDEX OF REFRACTION: .0002939 SCALE HEIGHT: 7284.10 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	867142.61	-.5774	867040.50	-1.0480	-.4228	867066.77	58676	50000	42941	52323
.5	797350.90	.0262	797269.91	-.1427	.1026	797278.00	56547	50000	47676	51054
1.0	736085.33	.6015	736018.88	.5372	.6594	736025.42	55083	50000	49187	50737
1.5	681621.76	1.1583	681565.85	1.1389	1.2046	681571.59	54036	50000	49776	50544
2.0	632873.46	1.7024	632825.47	1.7043	1.7394	632830.57	53263	50000	50025	50404
2.5	589067.36	2.2374	589025.49	2.2499	2.2666	589029.97	52679	50000	50131	50297
3.0	549603.95	2.7657	549566.93	2.7835	2.7891	549570.82	52230	50000	50173	50221
3.5	513990.52	3.2890	513957.42	3.3093	3.3092	513960.78	51878	50000	50184	50179
4.0	481803.11	3.8085	481773.23	3.8298	3.8286	481776.15	51598	50000	50181	50168
4.5	452667.99	4.3249	452640.79	4.3463	4.3484	452643.35	51372	50000	50171	50184
5.0	426251.27	4.8389	426226.34	4.8600	4.8621	426228.59	51188	50000	50159	50171
6.0	380438.62	5.8615	380417.29	5.8814	5.8797	380419.12	50910	50000	50132	50118
7.0	342386.14	6.8788	342367.53	6.8972	6.8938	342369.10	50715	50000	50109	50087
8.0	310516.88	7.8925	310500.39	7.9094	7.9052	310501.81	50574	50000	50091	50066
9.0	283597.35	8.9036	283582.56	8.9191	8.9146	283583.87	50470	50000	50077	50053
10.0	260661.36	9.9127	260647.95	9.9270	9.9225	260649.18	50391	50000	50066	50043
12.0	223884.01	11.9268	223872.72	11.9390	11.9347	223873.80	50279	50000	50048	50029
14.0	195916.57	13.9371	195906.82	13.9478	13.9438	195907.78	50208	50000	50036	50021
16.0	174075.64	15.9451	174067.05	15.9545	15.9508	174067.91	50160	50000	50028	50015
18.0	156626.66	17.9514	156618.98	17.9598	17.9564	156619.76	50126	50000	50023	50012
20.0	142415.83	19.9565	142408.88	19.9640	19.9610	142409.59	50102	50000	50019	50010
25.0	116413.75	24.9660	116408.10	24.9719	24.9694	116408.69	50064	50000	50013	50006
30.0	98942.92	29.9725	98938.15	29.9772	29.9752	98938.65	50043	50000	50009	50004
35.0	86542.06	34.9773	86537.90	34.9812	34.9795	86538.34	50029	50000	50006	50002
40.0	77393.35	39.9810	77389.64	39.9843	39.9829	77390.03	50021	50000	50005	50001
45.0	70459.15	44.9841	70455.76	44.9868	44.9857	70456.12	50015	50000	50004	50001
50.0	65107.27	49.9867	65104.15	49.9890	49.9880	65104.48	50011	50000	50003	50000
60.0	57667.87	59.9908	57665.11	59.9924	59.9917	57665.41	50007	50000	50003	50000
70.0	53185.76	69.9942	53183.21	69.9952	69.9948	53183.48	50004	50000	50002	50000
80.0	50768.00	79.9972	50765.57	79.9977	79.9975	50765.83	50003	50000	50002	50000
90.0	50002.40	90.0000	50000.00	90.0000	90.0000	50000.26	50002	50000	50002	50000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

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INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	1205849.49	-.6266	1205746.24	-1.4574	-.4745	1205773.61	112988	100000	82783	103153
.5	1135461.54	-.0138	1135379.90	-.3019	.0475	1135387.15	110029	100000	94387	101194
1.0	1072430.46	.5682	1072363.61	.4470	.6161	1072369.64	107962	100000	97776	100883
1.5	1015085.41	1.1299	1015029.24	1.0781	1.1698	1015034.68	106459	100000	99105	100695
2.0	962424.17	1.6778	962376.01	1.6592	1.7106	962380.91	105330	100000	99699	100542
2.5	913802.01	2.2158	913760.02	2.2142	2.2422	913764.37	104464	100000	99982	100415
3.0	868736.64	2.7464	868699.54	2.7541	2.7680	868703.33	103785	100000	100119	100321
3.5	826873.26	3.2717	826840.10	3.2842	3.2907	826843.40	103242	100000	100183	100269
4.0	787933.94	3.7927	787904.01	3.8079	3.8125	787906.87	102804	100000	100210	100266
4.5	751675.09	4.3104	751647.86	4.3269	4.3344	751650.38	102446	100000	100218	100309
5.0	717874.88	4.8255	717849.92	4.8426	4.8496	717852.15	102148	100000	100214	100296
6.0	656926.03	5.8499	656904.68	5.8668	5.8690	656906.48	101687	100000	100192	100213
7.0	603778.99	6.8687	603760.37	6.8847	6.8845	603761.92	101355	100000	100167	100162
8.0	557306.31	7.8835	557289.81	7.8984	7.8970	557291.21	101109	100000	100145	100129
9.0	516523.64	8.8954	516508.84	8.9093	8.9073	516510.14	100919	100000	100124	100103
10.0	480630.31	9.9053	480616.90	9.9182	9.9158	480618.11	100774	100000	100108	100086
12.0	420749.16	11.9205	420737.87	11.9317	11.9291	420738.94	100564	100000	100080	100060
14.0	373244.80	13.9317	373235.04	13.9415	13.9390	373235.99	100426	100000	100062	100044
16.0	334952.11	15.9403	334943.52	15.9490	15.9467	334944.37	100331	100000	100049	100034
18.0	303627.19	17.9472	303619.51	17.9549	17.9527	303620.28	100265	100000	100041	100028
20.0	277638.21	19.9527	277631.26	19.9597	19.9577	277631.97	100213	100000	100032	100021
25.0	229063.48	24.9629	229057.84	24.9684	24.9668	229058.42	100134	100000	100021	100013
30.0	195740.42	29.9700	195735.65	29.9745	29.9731	195736.14	100088	100000	100014	100008
35.0	171786.60	34.9753	171782.43	34.9789	34.9778	171782.87	100061	100000	100010	100005
40.0	153969.30	39.9793	153965.58	39.9824	39.9815	153965.97	100043	100000	100008	100004
45.0	140389.65	44.9827	140386.27	44.9852	44.9844	140386.63	100031	100000	100006	100002
50.0	129868.99	49.9854	129865.87	49.9876	49.9869	129866.20	100023	100000	100006	100002
60.0	115188.29	59.9900	115185.52	59.9915	59.9910	115185.81	100012	100000	100004	100001
70.0	106315.75	69.9937	106313.21	69.9946	69.9943	106313.48	100006	100000	100003	100000
80.0	101521.62	79.9969	101519.19	79.9974	79.9973	101519.45	100003	100000	100002	100000
90.0	100002.40	90.0000	100000.00	90.0000	90.0000	100000.26	100002	100000	100002	100000

**** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

APPENDIX E

TABULATED REFRACTION COMPARISON DATA FOR EDWARDS EHC-75 COLD DAY CONDITIONS

TABLE E-I

WEATHER DATA FOR EDWARDS ECA-75 COLD DAY

ALTITUDE (FT)	TEMPERATURE (DEG C)	DEW POINT (DEG C)	PRESSURE (MB)	N X 10E6
2316	-.00000	-4.15002	939.00000	289.57288
3000	-1.66439	-5.02664	909.01648	281.44360
4000	-2.48001	-5.65688	894.95471	277.35333
5000	-4.75101	-7.73210	857.09180	265.91949
6000	-7.37825	-10.15364	813.58728	252.78430
7000	-9.12493	-11.82637	785.50903	244.31665
8000	-11.07649	-13.87510	756.26953	235.54352
9000	-13.24860	-16.24633	724.61658	226.08044
10000	-15.25633	-18.48437	695.53406	217.41821
11000	-17.23049	-20.81900	667.78772	209.24750
12000	-19.27088	-23.35292	640.19519	201.20953
13000	-21.24707	-25.85493	614.24451	193.69794
14000	-23.21263	-28.41852	589.68994	186.66345
15000	-25.28627	-31.27077	565.09546	179.71649
16000	-27.26981	-34.09237	541.60950	173.10220
17000	-29.03263	-36.68136	519.72070	166.89542
18000	-30.74469	-39.27315	497.69263	160.63800
19000	-32.40592	-41.69907	476.33374	154.58017
20000	-34.00380	-43.74239	456.59601	149.00827
21000	-35.70151	-45.38656	437.04742	143.52994
22000	-37.43376	-46.81133	417.84619	138.15860
23000	-39.05200	-48.19875	399.96014	133.12823
24000	-40.65479	-49.71051	382.71515	128.21954
25000	-42.35757	-51.29106	365.55530	123.30487
26000	-44.08086	-52.80325	349.32440	118.66968
27000	-45.85164	-54.22858	334.10724	114.35422
28000	-47.71517	-55.75351	318.86243	109.98218
29000	-49.34718	-57.32469	304.25562	105.67955
30000	-50.39213	-58.91669	290.78082	101.48935
31000	-50.68689	-60.63559	277.44080	96.95177
32000	-50.63933	-62.21037	264.53351	92.38243
33000	-50.70688	-63.30237	252.63120	88.22917
34000	-50.91084	-63.58337	241.11481	84.28410
35000	-51.12187	-63.36666	229.87521	80.43756
36000	-51.32311	-63.15215	219.38391	76.84532
37000	-51.51958	-63.15002	209.48132	73.44798
38000	-51.72641	-63.15002	199.71237	70.09117
39000	-51.92905	-63.15002	190.47385	66.91438
40000	-52.12324	-63.15002	181.91086	63.96909
41000	-52.33182	-63.15002	173.44910	61.05466
42000	-52.54131	-63.15002	165.34671	58.26167
43000	-52.73788	-63.15002	157.88193	55.68760
44000	-52.94424	-63.15002	150.57849	53.16564
45000	-53.15488	-63.15002	143.50095	50.71882
46000	-53.35290	-63.15002	136.94308	48.45057
47000	-53.55122	-63.15002	130.65887	46.27430
48000	-53.75803	-63.15002	124.49812	44.13767
49000	-53.95930	-63.15002	118.71614	42.13139
50000	-54.15699	-63.15002	113.31422	40.25637

TABLE E-I -- Continued

WEATHER DATA FOR EDWARDS ECA-75 COLD DAY

ALTITUDE (FT)	TEMPERATURE (DEG C)	DEW POINT (DEG C)	PRESSURE (MB)	N X 10E6
51000	-54.36859	-63.15002	107.97940	38.40209
52000	-54.57560	-63.15002	102.90877	36.63802
53000	-54.76559	-63.15002	98.22827	35.00848
54000	-54.96605	-63.15002	93.61975	33.40137
55000	-55.17589	-63.15002	89.18549	31.85419
56000	-55.38883	-63.15002	85.09639	30.42875
57000	-55.61987	-63.15002	81.13026	29.04566
58000	-55.83823	-63.15002	77.27081	27.69601
59000	-55.99423	-63.15002	73.67717	26.43293
60000	-56.02567	-63.15002	70.28058	25.22466
61000	-55.95256	-63.15002	66.94150	24.02300
62000	-55.86035	-63.15002	63.79223	22.88678
63000	-55.80771	-63.15002	60.87077	21.83778
64000	-55.75486	-63.15002	57.99026	20.80436
65000	-55.70129	-63.15002	55.24083	19.81812
66000	-55.65079	-63.15002	52.70991	18.91033
67000	-55.59756	-63.15002	50.23737	18.02381
68000	-55.54401	-63.15002	47.85069	17.16836
69000	-55.49538	-63.15002	45.64375	16.37751
70000	-55.44862	-63.15002	43.52708	15.61938
71000	-55.39979	-63.15002	41.46027	14.87939
72000	-55.34921	-63.15002	39.52525	14.18654
73000	-55.29395	-63.15002	37.71385	13.53773
74000	-55.23518	-63.15002	35.92907	12.89865
75000	-55.18587	-63.15002	34.23690	12.29320
76000	-55.15603	-63.15002	32.67440	11.73494
77000	-55.12713	-63.15002	31.13794	11.18639
78000	-55.07240	-63.15002	29.66446	10.65940
79000	-54.96227	-63.15002	28.30800	10.17175
80000	-54.72646	-63.15002	26.99348	9.69412
81000	-54.41663	-63.15002	25.71885	9.22810
82000	-54.12528	-63.15002	24.53358	8.79516
83000	-53.86278	-63.15002	23.40822	8.38608
84000	-53.58611	-63.15002	22.30351	7.98526
85000	-53.31669	-63.15002	21.26414	7.60847
86000	-53.05879	-63.15002	20.30056	7.25936
87000	-52.78387	-63.15002	19.35302	6.91673
88000	-52.51028	-63.15002	18.45077	6.59085
89000	-52.25340	-63.15002	17.61901	6.29055
90000	-51.98228	-63.15002	16.80457	5.99705
91000	-51.70617	-63.15002	16.01958	5.71456
92000	-51.44562	-63.15002	15.29510	5.45394
93000	-51.17860	-63.15002	14.59926	5.20398
94000	-50.90123	-63.15002	13.92109	4.96076
95000	-50.63599	-63.15002	13.28648	4.73335
96000	-50.37910	-63.15002	12.68924	4.51955
97000	-50.10548	-63.15002	12.09976	4.30894
98000	-49.83197	-63.15002	11.54172	4.10969
99000	-49.56516	-63.15002	11.02721	3.92596
100000	-49.28035	-63.15002	10.52198	3.74586

COMPARISON OF GRADIENT (GMD), WHITE SANDS (CYBER) AND SPHERICAL SLAB (VARIAN) CORRECTION METHODS

BASED ON RESULTS OF GRADIENT REFRACTION SOLUTION FOR THE SAME MEASURED EL ANGLES AS USED IN JSC INTERNAL NOTE 75-FM-60

WEATHER DATA FOR EDWARDS ECA-75 COLD DAY SEA LEVEL INDEX OF REFRACTION: .0003164 SCALE HEIGHT: 6891.33 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	133569.05	-.1706	133528.49	-.1877	-.1733	133521.16	1398	1000	961	994
.5	76621.06	.4040	76598.21	.3977	.4005	76596.68	1129	1000	992	995
1.0	49392.03	.9387	49377.38	.9350	.9390	49377.05	1053	1000	997	1000
1.5	35480.70	1.4563	35470.19	1.4535	1.4571	35470.16	1027	1000	999	1000
2.0	27434.55	1.9664	27426.43	1.9641	1.9667	27426.47	1016	1000	999	1000
2.5	22283.21	2.4729	22276.62	2.4709	2.4726	22276.67	1011	1000	1000	1000
3.0	18730.10	2.9774	18724.56	2.9756	2.9767	18724.61	1008	1000	1000	1000
3.5	16141.11	3.4806	16136.34	3.4790	3.4798	16136.37	1006	1000	1000	1000
4.0	14174.81	3.9831	14170.62	3.9815	3.9825	14170.65	1004	1000	1000	1000
4.5	12632.59	4.4850	12628.86	4.4836	4.4850	12628.88	1004	1000	1000	1000
5.0	11391.57	4.9866	11388.21	4.9852	4.9860	11388.22	1003	1000	1000	1000
6.0	9519.86	5.9890	9517.05	5.9876	5.9883	9517.06	1002	1000	1000	1000
7.0	8176.44	6.9906	8174.03	6.9894	6.9899	8174.03	1002	1000	1000	1000
8.0	7166.10	7.9919	7163.98	7.9907	7.9912	7163.99	1001	1000	1000	1000
9.0	6379.32	8.9929	6377.43	8.9918	8.9921	6377.44	1001	1000	1000	1000
10.0	5749.45	9.9937	5747.75	9.9926	9.9929	5747.76	1001	1000	1000	1000
12.0	4804.81	11.9949	4803.39	11.9939	11.9941	4803.40	1001	1000	1000	1000
14.0	4130.78	13.9958	4129.56	13.9948	13.9950	4129.56	1001	1000	1000	1000
16.0	3626.28	15.9964	3625.21	15.9955	15.9956	3625.21	1000	1000	1000	1000
18.0	3235.00	17.9969	3234.04	17.9960	17.9961	3234.04	1000	1000	1000	1000
20.0	2923.24	19.9973	2922.38	19.9964	19.9966	2922.38	1000	1000	1000	1000
25.0	2366.11	24.9980	2365.42	24.9972	24.9973	2365.42	1000	1000	1000	1000
30.0	2000.02	29.9985	1999.43	29.9977	29.9978	1999.44	1000	1000	1000	1000
35.0	1743.61	34.9988	1743.10	34.9981	34.9982	1743.10	1000	1000	1000	1000
40.0	1555.98	39.9991	1555.52	39.9984	39.9985	1555.52	1000	1000	1000	1000
45.0	1414.52	44.9993	1414.10	44.9987	44.9987	1414.10	1000	1000	1000	1000
50.0	1305.55	49.9995	1305.17	49.9989	49.9989	1305.17	1000	1000	1000	1000
60.0	1154.88	59.9996	1154.54	59.9992	59.9993	1154.54	1000	1000	1000	1000
70.0	1064.37	69.9998	1064.06	69.9995	69.9995	1064.06	1000	1000	1000	1000
80.0	1015.63	79.9999	1015.33	79.9998	79.9998	1015.33	1000	1000	1000	1000
90.0	1000.20	90.0000	999.91	90.0000	90.0000	999.91	1000	1000	1000	1000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

COMPARISON OF GRADIENT (GMD), WHITE SANDS (CYBER) AND SPHERICAL SLAB (VARIAN) CORRECTION METHODS

BASED ON RESULTS OF GRADIENT REFRACTION SOLUTION FOR THE SAME MEASURED EL ANGLES AS USED IN JSC INTERNAL NOTE 75-FM-60

WEATHER DATA FOR EDWARDS ECA-75 COLD DAY SEA LEVEL INDEX OF REFRACTION: .0003164 SCALE HEIGHT: 6891.33 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	188252.45	-.2363	188196.99	-.2645	-.2375	188194.27	2778	2000	1909	1996
.5	125844.35	.3459	125808.28	.3371	.3394	125806.44	2339	2000	1981	1986
1.0	88790.68	.8925	88765.50	.8886	.8945	88765.27	2167	2000	1995	2003
1.5	66688.41	1.4198	66669.59	1.4175	1.4229	66669.84	2094	2000	1998	2004
2.0	52749.36	1.9368	52734.50	1.9352	1.9389	52734.86	2059	2000	1999	2002
2.5	43386.50	2.4482	43374.30	2.4469	2.4492	43374.64	2040	2000	2000	2001
3.0	36743.93	2.9563	36733.60	2.9551	2.9564	36733.90	2029	2000	2000	2000
3.5	31817.38	3.4623	31808.44	3.4612	3.4621	31808.69	2021	2000	2000	2000
4.0	28032.14	3.9669	28024.27	3.9659	3.9671	28024.48	2017	2000	2000	2000
4.5	25039.11	4.4706	25032.08	4.4696	4.4717	25032.26	2013	2000	2000	2000
5.0	22616.89	4.9735	22610.54	4.9725	4.9739	22610.68	2011	2000	2000	2000
6.0	18941.96	5.9780	18936.64	5.9771	5.9780	18936.75	2008	2000	2000	2000
7.0	16290.85	6.9812	16286.27	6.9803	6.9810	16286.37	2006	2000	2000	2000
8.0	14290.87	7.9837	14286.85	7.9828	7.9833	14286.93	2005	2000	2000	2000
9.0	12729.40	8.9856	12725.83	8.9847	8.9851	12725.90	2004	2000	2000	2000
10.0	11477.61	9.9871	11474.39	9.9862	9.9866	11474.45	2003	2000	2000	2000
12.0	9597.26	11.9894	9594.57	11.9886	11.9888	9594.63	2002	2000	2000	2000
14.0	8253.79	13.9911	8251.48	13.9903	13.9905	8251.53	2002	2000	2000	2000
16.0	7247.40	15.9923	7245.37	15.9915	15.9917	7245.41	2001	2000	2000	2000
18.0	6466.58	17.9933	6464.76	17.9925	17.9927	6464.80	2001	2000	2000	2000
20.0	5843.88	19.9941	5842.24	19.9933	19.9934	5842.27	2001	2000	2000	2000
25.0	4730.95	24.9955	4729.62	24.9948	24.9949	4729.65	2001	2000	2000	2000
30.0	3999.51	29.9965	3998.39	29.9958	29.9959	3998.41	2001	2000	2000	2000
35.0	3486.97	34.9972	3486.00	34.9965	34.9966	3486.02	2001	2000	2001	2000
40.0	3111.67	39.9977	3110.80	39.9971	39.9971	3110.82	2001	2000	2000	2000
45.0	2828.84	44.9981	2828.05	44.9976	44.9976	2828.06	2001	2000	2001	2000
50.0	2611.17	49.9985	2610.44	49.9980	49.9980	2610.45	2000	2000	2000	2000
60.0	2309.88	59.9990	2309.24	59.9986	59.9986	2309.25	2001	2000	2000	2000
70.0	2128.89	69.9994	2128.30	69.9991	69.9991	2128.31	2001	2000	2001	2000
80.0	2031.24	79.9997	2030.67	79.9996	79.9996	2030.68	2000	2000	2000	2000
90.0	2000.40	90.0000	1999.83	90.0000	90.0000	1999.85	2000	2000	2000	2000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

COMPARISON OF GRADIENT (GMD), WHITE SANDS (CYBER) AND SPHERICAL SLAB (VARIAN) CORRECTION METHODS

BASED ON RESULTS OF GRADIENT REFRACTION SOLUTION FOR THE SAME MEASURED EL ANGLES AS USED IN JSC INTERNAL NOTE 75-FM-60

WEATHER DATA FOR EDWARDS ECA-75 COLD DAY SEA LEVEL INDEX OF REFRACTION: .0003164 SCALE HEIGHT: 6891.33 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	294816.03	-.3515	294737.10	-.4142	-.2948	294745.64	6810	5000	4680	5291
.5	227379.16	.2397	227321.29	.2231	.2419	227321.59	6034	5000	4937	5009
1.0	178832.12	.8000	178787.87	.7977	.8075	178789.08	5626	5000	4995	5024
1.5	144178.37	1.3409	144143.26	1.3433	1.3501	144144.87	5401	5000	5008	5023
2.0	119212.51	1.8696	119183.76	1.8734	1.8771	119185.37	5272	5000	5009	5016
2.5	100846.80	2.3904	100822.61	2.3944	2.3954	100824.06	5194	5000	5009	5009
3.0	86991.96	2.9058	86971.18	2.9098	2.9090	86972.43	5144	5000	5007	5005
3.5	76275.15	3.4177	76256.97	3.4214	3.4201	76258.03	5111	5000	5006	5003
4.0	67792.75	3.9271	67776.63	3.9305	3.9300	67777.51	5087	5000	5005	5004
4.5	60940.86	4.4347	60926.38	4.4377	4.4395	60927.14	5070	5000	5004	5005
5.0	55306.65	4.9408	55293.52	4.9436	4.9454	55294.17	5058	5000	5004	5004
6.0	46618.47	5.9504	46607.42	5.9527	5.9533	46607.92	5041	5000	5003	5002
7.0	40255.19	6.9574	40245.66	6.9593	6.9594	40246.07	5031	5000	5003	5001
8.0	35407.19	7.9627	35398.81	7.9644	7.9641	35399.17	5024	5000	5002	5001
9.0	31597.46	8.9669	31589.99	8.9683	8.9679	31590.31	5019	5000	5002	5001
10.0	28528.56	9.9702	28521.81	9.9715	9.9710	28522.11	5016	5000	5002	5000
12.0	23896.86	11.9753	23891.21	11.9763	11.9758	23891.47	5011	5000	5002	5000
14.0	20573.82	13.9790	20568.96	13.9798	13.9792	20569.18	5008	5000	5001	5000
16.0	18078.15	15.9818	18073.87	15.9824	15.9819	18074.07	5007	5000	5001	5000
18.0	16138.20	17.9840	16134.38	17.9844	17.9840	16134.56	5005	5000	5001	5000
20.0	14589.30	19.9858	14585.85	19.9861	19.9857	14586.02	5005	5000	5001	5000
25.0	11817.34	24.9890	11814.55	24.9892	24.9888	11814.68	5003	5000	5001	5000
30.0	9993.19	29.9912	9990.83	29.9912	29.9909	9990.94	5002	5000	5001	5000
35.0	8713.79	34.9928	8711.73	34.9928	34.9925	8711.83	5002	5000	5001	5000
40.0	7777.03	39.9941	7775.20	39.9940	39.9938	7775.28	5002	5000	5001	5000
45.0	7070.53	44.9951	7068.86	44.9949	44.9948	7068.94	5002	5000	5001	5000
50.0	6527.10	49.9959	6525.56	49.9958	49.9956	6525.63	5001	5000	5001	5000
60.0	5774.21	59.9972	5772.85	59.9971	59.9970	5772.92	5001	5000	5001	5000
70.0	5321.83	69.9983	5320.57	69.9982	69.9981	5320.63	5001	5000	5001	5000
80.0	5078.23	79.9992	5077.03	79.9991	79.9991	5077.09	5001	5000	5001	5000
90.0	5001.14	90.0000	4999.96	90.0000	90.0000	5000.01	5001	5000	5001	5000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

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BASED ON RESULTS OF GRADIENT REFRACTION SOLUTION FOR THE SAME MEASURED EL ANGLES AS USED IN JSC INTERNAL NOTE 75-FM-60

WEATHER DATA FOR EDWARDS ECA-75 COLD DAY SEA LEVEL INDEX OF REFRACTION: .0003164 SCALE HEIGHT: 6891.33 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	411426.01	-.4535	411330.33	-.5781	-.3328	411349.95	13256	10000	9112	10866
.5	341565.48	.1453	341491.90	.1102	.1984	341497.49	12115	10000	9795	10317
1.0	286608.07	.7140	286549.36	.7099	.7507	286553.99	11431	10000	9982	10183
1.5	243374.73	1.2637	243326.53	1.2712	1.2914	243330.72	11005	10000	10034	10118
2.0	209297.67	1.8006	209257.14	1.8124	1.8213	209260.89	10729	10000	10045	10076
2.5	182269.10	2.3287	182234.35	2.3417	2.3435	182237.62	10546	10000	10044	10047
3.0	160621.38	2.8505	160591.09	2.8635	2.8612	160593.89	10420	10000	10039	10030
3.5	143079.20	3.3678	143052.43	3.3804	3.3764	143054.80	10331	10000	10033	10022
4.0	128686.18	3.8818	128662.24	3.8936	3.8905	128664.27	10267	10000	10029	10020
4.5	116730.38	4.3932	116708.76	4.4044	4.4044	116710.51	10219	10000	10025	10023
5.0	106681.98	4.9028	106662.29	4.9132	4.9144	106663.80	10182	10000	10021	10022
6.0	90815.85	5.9178	90799.16	5.9269	5.9260	90800.36	10131	10000	10016	10013
7.0	78925.53	6.9289	78911.07	6.9369	6.9351	78912.08	10099	10000	10013	10009
8.0	69725.40	7.9375	69712.65	7.9446	7.9424	69713.55	10077	10000	10010	10006
9.0	62417.14	8.9443	62405.75	8.9507	8.9483	62406.57	10062	10000	10009	10004
10.0	56483.61	9.9499	56473.31	9.9556	9.9532	56474.06	10050	10000	10007	10003
12.0	47457.24	11.9583	47448.60	11.9630	11.9607	47449.25	10036	10000	10006	10002
14.0	40934.67	13.9644	40927.22	13.9684	13.9663	40927.79	10026	10000	10005	10001
16.0	36013.58	15.9691	36007.03	15.9725	15.9706	36007.54	10020	10000	10004	10001
18.0	32176.48	17.9727	32170.63	17.9757	17.9739	32171.09	10016	10000	10003	10001
20.0	29106.06	19.9757	29100.77	19.9783	19.9767	29101.19	10013	10000	10003	10001
25.0	23598.26	24.9811	23593.98	24.9831	24.9817	23594.32	10009	10000	10003	10000
30.0	19965.99	29.9848	19962.36	29.9863	29.9852	19962.66	10006	10000	10002	10000
35.0	17415.24	34.9875	17412.08	34.9887	34.9878	17412.34	10005	10000	10002	10000
40.0	15546.10	39.9896	15543.28	39.9906	39.9898	15543.50	10004	10000	10002	10000
45.0	14135.74	44.9913	14133.17	44.9921	44.9915	14133.38	10003	10000	10002	10000
50.0	13050.63	49.9927	13048.26	49.9934	49.9928	13048.45	10003	10000	10002	10000
60.0	11546.61	59.9950	11544.51	59.9954	59.9951	11544.68	10002	10000	10002	10000
70.0	10642.78	69.9969	10640.84	69.9971	69.9969	10641.00	10002	10000	10002	10000
80.0	10155.85	79.9985	10154.01	79.9986	79.9985	10154.16	10002	10000	10002	10000
90.0	10001.77	90.0000	9999.96	90.0000	90.0000	10000.10	10002	10000	10002	10000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

COMPARISON OF GRADIENT (GMD), WHITE SANDS (CYBER) AND SPHERICAL SLAB (VARIAN) CORRECTION METHODS

BASED ON RESULTS OF GRADIENT REFRACTION SOLUTION FOR THE SAME MEASURED EL ANGLES AS USED IN JSC INTERNAL NOTE 75-FM-60

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INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	570798.50	-.5522	570692.98	-.8020	-.3987	570720.25	25490	20000	17527	21527
.5	499365.79	.0562	499283.34	-.0245	.1381	499292.11	23862	20000	19306	20713
1.0	439978.48	.6331	439911.61	.6125	.6925	439918.45	22813	20000	19848	20455
1.5	390156.13	1.1900	390100.40	1.1941	1.2353	390106.23	22108	20000	20033	20308
2.0	348176.77	1.7334	348129.29	1.7482	1.7681	348134.33	21618	20000	20094	20210
2.5	312685.92	2.2673	312644.76	2.2866	2.2934	312649.07	21268	20000	20109	20142
3.0	282569.46	2.7943	282533.25	2.8153	2.8142	282536.91	21013	20000	20106	20098
3.5	256900.24	3.3162	256868.00	3.3374	3.3327	256871.09	20823	20000	20098	20074
4.0	234909.27	3.8343	234880.27	3.8550	3.8504	234882.91	20679	20000	20087	20066
4.5	215963.26	4.3493	215936.94	4.3692	4.3683	215939.21	20567	20000	20078	20071
5.0	199543.98	4.8620	199519.91	4.8811	4.8812	199521.89	20480	20000	20069	20066
6.0	172674.58	5.8823	172654.06	5.8994	5.8966	172655.64	20354	20000	20054	20043
7.0	151778.65	6.8976	151760.80	6.9130	6.9089	151762.15	20271	20000	20043	20030
8.0	135174.45	7.9096	135158.66	7.9235	7.9188	135159.88	20213	20000	20035	20022
9.0	121724.27	8.9192	121710.13	8.9318	8.9270	121711.25	20171	20000	20029	20016
10.0	110642.73	9.9270	110629.93	9.9385	9.9337	110630.97	20141	20000	20024	20013
12.0	93526.99	11.9390	93516.22	11.9487	11.9443	93517.14	20099	20000	20018	20009
14.0	80981.42	13.9478	80972.12	13.9562	13.9521	80972.94	20074	20000	20014	20006
16.0	71428.06	15.9545	71419.89	15.9618	15.9581	71420.61	20057	20000	20011	20005
18.0	63931.52	17.9598	63924.21	17.9663	17.9629	63924.87	20045	20000	20009	20003
20.0	57905.70	19.9641	57899.09	19.9698	19.9668	57899.69	20036	20000	20008	20003
25.0	47042.54	24.9720	47037.18	24.9764	24.9740	47037.67	20023	20000	20006	20002
30.0	39845.63	29.9774	39841.09	29.9809	29.9789	39841.51	20016	20000	20004	20001
35.0	34778.44	34.9814	34774.48	34.9843	34.9826	34774.85	20012	20000	20004	20001
40.0	31059.19	39.9845	31055.66	39.9869	39.9855	31055.99	20009	20000	20003	20001
45.0	28249.78	44.9870	28246.57	44.9890	44.9878	28246.87	20007	20000	20003	20000
50.0	26086.58	49.9891	26083.61	49.9908	49.9898	26083.89	20005	20000	20003	20000
60.0	23086.34	59.9925	23083.71	59.9936	59.9930	23083.96	20004	20000	20002	20000
70.0	21282.20	69.9953	21279.78	69.9960	69.9956	21280.01	20003	20000	20002	20000
80.0	20309.98	79.9977	20307.68	79.9981	79.9978	20307.89	20002	20000	20002	20000
90.0	20002.27	90.0000	19999.99	90.0000	90.0000	20000.21	20002	20000	20002	20000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

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INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	876249.10	-.6528	876139.62	-1.2312	-.4986	876170.42	59909	50000	41230	52341
.5	803553.69	-.0295	803468.34	-.2314	.0327	803476.23	57372	50000	47198	50864
1.0	740485.32	.5586	740416.13	.4803	.6062	740422.45	55664	50000	49003	50609
1.5	684838.99	1.1241	684781.28	1.0975	1.1629	684786.79	54461	50000	49690	50459
2.0	635285.21	1.6743	635236.00	1.6719	1.7056	635240.81	53584	50000	49977	50342
2.5	590914.02	2.2139	590871.29	2.2233	2.2383	590875.43	52929	50000	50101	50249
3.0	551044.95	2.7456	551007.32	2.7610	2.7649	551010.83	52428	50000	50151	50183
3.5	515131.31	3.2715	515097.75	3.2899	3.2882	515100.71	52038	50000	50167	50148
4.0	482720.05	3.7930	482689.82	3.8126	3.8105	482692.33	51730	50000	50167	50146
4.5	453415.60	4.3110	453388.14	4.3310	4.3330	453390.29	51483	50000	50160	50172
5.0	426864.84	4.8264	426839.70	4.8462	4.8489	426841.57	51282	50000	50149	50166
6.0	380866.11	5.8510	380844.64	5.8698	5.8685	380846.12	50979	50000	50125	50113
7.0	342692.16	6.8699	342673.46	6.8872	6.8840	342674.74	50768	50000	50103	50082
8.0	310742.25	7.8847	310725.69	7.9007	7.8966	310726.85	50616	50000	50086	50062
9.0	283767.11	8.8966	283752.27	8.9113	8.9070	283753.35	50503	50000	50073	50049
10.0	260791.90	9.9065	260778.45	9.9200	9.9155	260779.47	50418	50000	50063	50040
12.0	223965.70	11.9216	223954.38	11.9332	11.9289	223955.29	50299	50000	50046	50027
14.0	195970.26	13.9327	195960.49	13.9429	13.9389	195961.30	50222	50000	50034	50019
16.0	174112.54	15.9413	174103.94	15.9502	15.9466	174104.67	50171	50000	50027	50014
18.0	156652.94	17.9480	156645.25	17.9560	17.9526	156645.91	50135	50000	50021	50011
20.0	142435.10	19.9535	142428.14	19.9606	19.9576	142428.75	50109	50000	50018	50009
25.0	116423.56	24.9636	116417.91	24.9692	24.9668	116418.41	50069	50000	50012	50006
30.0	98948.41	29.9706	98943.64	29.9751	29.9731	98944.06	50045	50000	50008	50003
35.0	86545.35	34.9757	86541.18	34.9795	34.9778	86541.56	50031	50000	50006	50002
40.0	77395.41	39.9797	77391.69	39.9828	39.9814	77392.02	50022	50000	50005	50001
45.0	70460.47	44.9830	70457.08	44.9856	44.9844	70457.39	50016	50000	50004	50001
50.0	65108.13	49.9857	65105.01	49.9879	49.9869	65105.29	50012	50000	50003	50000
60.0	57668.24	59.9902	57665.47	59.9917	59.9910	57665.72	50007	50000	50003	50000
70.0	53185.89	69.9938	53183.34	69.9948	69.9943	53183.58	50004	50000	50002	50000
80.0	50768.03	79.9970	50765.60	79.9975	79.9972	50765.82	50003	50000	50002	50000
90.0	50002.40	90.0000	50000.00	90.0000	90.0000	50000.22	50002	50000	50002	50000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

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E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	1215254.84	-.7059	1215144.01	-1.7075	-.5557	1215176.10	114741	100000	79072	103138
.5	1141960.34	-.0719	1141874.24	-.4052	-.0282	1141881.92	111225	100000	93469	100856
1.0	1077122.28	.5237	1077052.65	.3842	.5591	1077058.35	108820	100000	97428	100655
1.5	1018588.46	1.0947	1018530.47	1.0335	1.1256	1018535.62	107098	100000	98939	100541
2.0	965108.67	1.6491	965059.28	1.6247	1.6751	965063.88	105821	100000	99603	100430
2.5	915912.14	2.1917	915869.29	2.1862	2.2126	915873.30	104853	100000	99920	100328
3.0	870423.64	2.7260	870385.92	2.7305	2.7428	870389.33	104098	100000	100073	100250
3.5	828247.23	3.2539	828213.61	3.2639	3.2690	828216.50	103500	100000	100147	100213
4.0	789069.01	3.7770	789038.73	3.7900	3.7938	789041.19	103020	100000	100180	100226
4.5	752621.29	4.2964	752593.79	4.3110	4.3185	752595.91	102629	100000	100192	100284
5.0	718674.07	4.8130	718648.90	4.8282	4.8361	718650.74	102305	100000	100192	100284
6.0	657509.24	5.8395	657487.76	5.8548	5.8575	657489.21	101806	100000	100175	100201
7.0	604216.74	6.8597	604198.02	6.8744	6.8745	604199.28	101448	100000	100154	100151
8.0	557641.11	7.8756	557624.55	7.8894	7.8882	557625.69	101183	100000	100134	100119
9.0	516785.77	8.8885	516770.92	8.9013	8.8995	516771.99	100980	100000	100114	100095
10.0	480837.62	9.8990	480824.17	9.9110	9.9088	480825.18	100824	100000	100100	100079
12.0	420884.96	11.9153	420873.64	11.9257	11.9233	420874.54	100600	100000	100074	100055
14.0	373337.36	13.9273	373327.59	13.9364	13.9340	373328.39	100454	100000	100058	100040
16.0	335017.57	15.9365	335008.97	15.9445	15.9423	335009.69	100352	100000	100045	100030
18.0	303674.71	17.9438	303667.01	17.9510	17.9489	303667.67	100282	100000	100038	100025
20.0	277673.72	19.9497	277666.76	19.9562	19.9542	277667.36	100227	100000	100030	100019
25.0	229081.96	24.9606	229076.31	24.9657	24.9641	229076.81	100142	100000	100020	100012
30.0	195750.95	29.9681	195746.17	29.9723	29.9709	195746.59	100094	100000	100013	100007
35.0	171792.95	34.9737	171788.79	34.9771	34.9760	171789.16	100065	100000	100010	100005
40.0	153973.30	39.9780	153969.58	39.9809	39.9800	153969.91	100046	100000	100007	100003
45.0	140392.24	44.9816	140388.85	44.9840	44.9832	140389.16	100033	100000	100006	100002
50.0	129870.68	49.9845	129867.56	49.9865	49.9859	129867.84	100025	100000	100005	100002
60.0	115189.00	59.9894	115186.24	59.9907	59.9903	115186.48	100013	100000	100003	100001
70.0	106316.02	69.9933	106313.47	69.9942	69.9939	106313.70	100006	100000	100003	100000
80.0	101521.68	79.9967	101519.25	79.9972	79.9970	101519.47	100003	100000	100002	100000
90.0	100002.40	90.0000	100000.00	90.0000	90.0000	100000.22	100002	100000	100002	100000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

APPENDIX F

TABULATED REFRACTION COMPARISON DATA FOR EDWARDS TYPICAL COLD MOIST MORNING

TABLE F-I

WEATHER DATA FOR TYPICAL COLD-MOIST MORNING

ALTITUDE (FT)	TEMPERATURE (DEG C)	DEW POINT (DEG C)	PRESSURE (MB)	N X 10E6
2316	-7.15002	-7.15002	939.00000	293.07935
3000	-3.74665	-8.05864	909.01648	279.30591
4000	-3.21093	-10.03486	894.95471	273.11621
5000	-3.71509	-17.29132	857.09180	257.53223
6000	-4.57112	-25.27481	813.58728	240.18613
7000	-5.85618	-29.43772	785.50903	230.49646
8000	-8.76741	-31.32787	756.26953	223.78452
9000	-12.37808	-32.37266	724.61658	217.63535
10000	-15.34153	-33.30928	695.53406	211.48535
11000	-17.51992	-34.02937	667.78772	204.74118
12000	-19.42188	-34.49619	640.19519	197.72952
13000	-21.24974	-35.05724	614.24451	191.08826
14000	-23.21263	-36.03225	589.68994	184.83401
15000	-25.28627	-37.34002	565.09546	178.45306
16000	-27.26981	-38.67367	541.60950	172.28491
17000	-29.03263	-39.82956	519.72070	166.45926
18000	-30.74469	-41.04211	497.69263	160.42966
19000	-32.40592	-42.29614	476.33374	154.50446
20000	-34.00380	-43.55772	456.59601	149.03824
21000	-35.70151	-45.04784	437.04742	143.58487
22000	-37.43376	-46.66737	417.84619	138.18195
23000	-39.05200	-48.19875	399.96014	133.12823
24000	-40.65479	-49.71051	382.71515	128.21954
25000	-42.35757	-51.29106	365.55530	123.30487
26000	-44.08086	-52.80325	349.32440	118.66968
27000	-45.85164	-54.22858	334.10724	114.35422
28000	-47.71517	-55.75351	318.86243	109.98218
29000	-49.34718	-57.32469	304.25562	105.67955
30000	-50.39213	-58.91669	290.78082	101.48935
31000	-50.68689	-60.63559	277.44080	96.95177
32000	-50.63933	-62.21037	264.53351	92.38243
33000	-50.70688	-63.30237	252.63120	88.22917
34000	-50.91084	-63.58337	241.11481	84.28410
35000	-51.12187	-63.36666	229.87521	80.43756
36000	-51.32311	-63.15215	219.38391	76.84532
37000	-51.51958	-63.15002	209.48132	73.44798
38000	-51.72641	-63.15002	199.71237	70.09117
39000	-51.92905	-63.15002	190.47385	66.91438
40000	-52.12324	-63.15002	181.91086	63.96909
41000	-52.33182	-63.15002	173.44910	61.05466
42000	-52.54131	-63.15002	165.34671	58.26167
43000	-52.73788	-63.15002	157.88193	55.68760
44000	-52.94424	-63.15002	150.57849	53.16564
45000	-53.15488	-63.15002	143.50095	50.71882
46000	-53.35290	-63.15002	136.94308	48.45057
47000	-53.55122	-63.15002	130.65887	46.27430
48000	-53.75803	-63.15002	124.49812	44.13767
49000	-53.95930	-63.15002	118.71614	42.13139
50000	-54.15699	-63.15002	113.31422	40.25637

TABLE F-I -- Continued

WEATHER DATA FOR TYPICAL COLD-MOIST MORNING

ALTITUDE (FT)	TEMPERATURE (DEG C)	DEW POINT (DEG C)	PRESSURE (MB)	N X 10E6
2316	-7.15002	-7.15002	939.00000	293.07935
3000	-3.74665	-8.05864	909.01648	279.30591
4000	-3.21093	-10.03486	894.95471	273.11621
5000	-3.71509	-17.29132	857.09180	257.53223
6000	-4.57112	-25.27481	813.58728	240.18613
7000	-5.85618	-29.43772	785.50903	230.49646
8000	-8.76741	-31.32787	756.26953	223.78452
9000	-12.37808	-32.37266	724.61658	217.63535
10000	-15.34153	-33.30928	695.53406	211.48535
11000	-17.51992	-34.02937	667.78772	204.74118
12000	-19.42188	-34.49619	640.19519	197.72952
13000	-21.24974	-35.05724	614.24451	191.08826
14000	-23.21263	-36.03225	589.68994	184.83401
15000	-25.28627	-37.34002	565.09546	178.45306
16000	-27.26981	-38.67367	541.60950	172.28491
17000	-29.03263	-39.82956	519.72070	166.45926
18000	-30.74469	-41.04211	497.69263	160.42966
19000	-32.40592	-42.29614	476.33374	154.50446
20000	-34.00380	-43.55772	456.59601	149.03824
21000	-35.70151	-45.04784	437.04742	143.58487
22000	-37.43376	-46.66737	417.84619	138.18195
23000	-39.05200	-48.19875	399.96014	133.12823
24000	-40.65479	-49.71051	382.71515	128.21954
25000	-42.35757	-51.29106	365.55530	123.30487
26000	-44.08086	-52.80325	349.32440	118.66968
27000	-45.85164	-54.22858	334.10724	114.35422
28000	-47.71517	-55.75351	318.86243	109.98218
29000	-49.34718	-57.32469	304.25562	105.67955
30000	-50.39213	-58.91669	290.78082	101.48935
31000	-50.68689	-60.63559	277.44080	96.95177
32000	-50.63933	-62.21037	264.53351	92.38243
33000	-50.70688	-63.30237	252.63120	88.22917
34000	-50.91084	-63.58337	241.11481	84.28410
35000	-51.12187	-63.36666	229.87521	80.43756
36000	-51.32311	-63.15215	219.38391	76.84532
37000	-51.51958	-63.15002	209.48132	73.44798
38000	-51.72641	-63.15002	199.71237	70.09117
39000	-51.92905	-63.15002	190.47385	66.91438
40000	-52.12324	-63.15002	181.91086	63.96909
41000	-52.33182	-63.15002	173.44910	61.05466
42000	-52.54131	-63.15002	165.34671	58.26167
43000	-52.73788	-63.15002	157.88193	55.68760
44000	-52.94424	-63.15002	150.57849	53.16564
45000	-53.15488	-63.15002	143.50095	50.71882
46000	-53.35290	-63.15002	136.94308	48.45057
47000	-53.55122	-63.15002	130.65887	46.27430
48000	-53.75803	-63.15002	124.49812	44.13767
49000	-53.95930	-63.15002	118.71614	42.13139
50000	-54.15699	-63.15002	113.31422	40.25637

COMPARISON OF GRADIENT (GMD), WHITE SANDS (CYBER) AND SPHERICAL SLAB (VARIAN) CORRECTION METHODS

BASED ON RESULTS OF GRADIENT REFRACTION SOLUTION FOR THE SAME MEASURED EL ANGLES AS USED IN JSC INTERNAL NOTE 75-FM-60

WEATHER DATA FOR TYPICAL COLD-MOIST MORNING SEA LEVEL INDEX OF REFRACTION: .0003226 SCALE HEIGHT: 6779.43 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	134527.58	-.1780	134486.06	-.1966	-.1808	134478.67	1419	1000	957	993
.5	76880.32	.4003	76857.08	.3933	.3966	76855.35	1134	1000	991	995
1.0	49471.50	.9365	49456.63	.9323	.9367	49456.21	1055	1000	997	1000
1.5	35511.63	1.4547	35500.98	1.4517	1.4555	35500.89	1028	1000	998	1000
2.0	27449.16	1.9652	27440.94	1.9627	1.9655	27440.93	1017	1000	999	1000
2.5	22291.13	2.4720	22284.45	2.4698	2.4716	22284.46	1011	1000	999	1000
3.0	18734.83	2.9766	18729.22	2.9746	2.9758	18729.23	1008	1000	1000	1000
3.5	16144.15	3.4799	16139.31	3.4782	3.4791	16139.32	1006	1000	1000	1000
4.0	14176.87	3.9825	14172.63	3.9808	3.9819	14172.63	1005	1000	1000	1000
4.5	12634.05	4.4845	12630.27	4.4829	4.4845	12630.27	1004	1000	1000	1000
5.0	11392.65	4.9861	11389.24	4.9846	4.9855	11389.24	1003	1000	1000	1000
6.0	9520.49	5.9886	9517.64	5.9872	5.9879	9517.64	1002	1000	1000	1000
7.0	8176.85	6.9903	8174.40	6.9890	6.9896	8174.39	1002	1000	1000	1000
8.0	7166.37	7.9916	7164.23	7.9904	7.9908	7164.22	1001	1000	1000	1000
9.0	6379.51	8.9927	6377.61	8.9915	8.9919	6377.60	1001	1000	1000	1000
10.0	5749.60	9.9935	5747.88	9.9923	9.9927	5747.87	1001	1000	1000	1000
12.0	4804.90	11.9947	4803.46	11.9936	11.9939	4803.46	1001	1000	1000	1000
14.0	4130.84	13.9956	4129.60	13.9946	13.9948	4129.60	1001	1000	1000	1000
16.0	3626.32	15.9963	3625.23	15.9953	15.9955	3625.23	1001	1000	1000	1000
18.0	3235.03	17.9968	3234.06	17.9958	17.9960	3234.06	1000	1000	1000	1000
20.0	2923.27	19.9972	2922.39	19.9963	19.9964	2922.39	1000	1000	1000	1000
25.0	2366.13	24.9980	2365.42	24.9971	24.9972	2365.42	1000	1000	1000	1000
30.0	2000.04	29.9985	1999.44	29.9977	29.9978	1999.44	1000	1000	1000	1000
35.0	1743.62	34.9988	1743.10	34.9981	34.9981	1743.10	1000	1000	1000	1000
40.0	1555.99	39.9991	1555.52	39.9984	39.9985	1555.52	1000	1000	1000	1000
45.0	1414.53	44.9993	1414.10	44.9986	44.9987	1414.10	1000	1000	1000	1000
50.0	1305.56	49.9995	1305.17	49.9989	49.9989	1305.16	1000	1000	1000	1000
60.0	1154.88	59.9996	1154.54	59.9992	59.9992	1154.54	1000	1000	1000	1000
70.0	1064.38	69.9998	1064.06	69.9995	69.9995	1064.06	1000	1000	1000	1000
80.0	1015.63	79.9999	1015.33	79.9998	79.9998	1015.33	1000	1000	1000	1000
90.0	1000.21	90.0000	999.91	90.0000	90.0000	999.91	1000	1000	1000	1000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

COMPARISON OF GRADIENT (GMD), WHITE SANDS (CYBER) AND SPHERICAL SLAB (VARIAN) CORRECTION METHODS

BASED ON RESULTS OF GRADIENT REFRACTION SOLUTION FOR THE SAME MEASURED EL ANGLES AS USED IN JSC INTERNAL NOTE 75-FM-60

WEATHER DATA FOR TYPICAL COLD-MOIST MORNING SEA LEVEL INDEX OF REFRACTION: .0003226 SCALE HEIGHT: 6779.43 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	189399.58	-.2452	189343.59	-.2768	-.2474	189340.33	2811	2000	1897	1993
.5	126237.21	.3413	126201.15	.3303	.3332	126198.42	2350	2000	1977	1982
1.0	88936.81	.8897	88911.75	.8843	.8906	88910.88	2172	2000	1992	2001
1.5	66751.75	1.4178	66733.06	1.4143	1.4201	66732.83	2096	2000	1997	2003
2.0	52781.07	1.9354	52766.34	1.9327	1.9368	52766.31	2060	2000	1998	2001
2.5	43404.23	2.4471	43392.13	2.4449	2.4474	43392.15	2041	2000	1999	2000
3.0	36754.68	2.9554	36744.45	2.9534	2.9549	36744.47	2029	2000	1999	2000
3.5	31824.36	3.4615	31815.51	3.4598	3.4608	31815.52	2022	2000	2000	2000
4.0	28036.89	3.9662	28029.09	3.9646	3.9659	28029.09	2017	2000	2000	2000
4.5	25042.49	4.4699	25035.53	4.4684	4.4707	25035.51	2014	2000	2000	2000
5.0	22619.35	4.9729	22613.07	4.9715	4.9730	22613.04	2011	2000	2000	2000
6.0	18943.39	5.9775	18938.13	5.9762	5.9772	18938.10	2008	2000	2000	2000
7.0	16291.75	6.9808	16287.22	6.9796	6.9803	16287.19	2006	2000	2000	2000
8.0	14291.46	7.9833	14287.48	7.9821	7.9827	14287.45	2005	2000	2000	2000
9.0	12729.82	8.9852	12726.28	8.9841	8.9846	12726.25	2004	2000	2000	2000
10.0	11477.90	9.9868	11474.72	9.9857	9.9861	11474.69	2003	2000	2000	2000
12.0	9597.42	11.9892	9594.76	11.9882	11.9884	9594.74	2002	2000	2000	2000
14.0	8253.89	13.9909	8251.59	13.9899	13.9901	8251.58	2002	2000	2000	2000
16.0	7247.46	15.9921	7245.45	15.9912	15.9914	7245.44	2001	2000	2000	2000
18.0	6466.62	17.9931	6464.82	17.9922	17.9924	6464.81	2001	2000	2000	2000
20.0	5843.90	19.9940	5842.28	19.9931	19.9932	5842.27	2001	2000	2000	2000
25.0	4730.96	24.9954	4729.65	24.9946	24.9947	4729.64	2001	2000	2000	2000
30.0	3999.52	29.9964	3998.41	29.9956	29.9957	3998.40	2001	2000	2000	2000
35.0	3486.97	34.9971	3486.00	34.9964	34.9965	3486.00	2001	2000	2001	2000
40.0	3111.67	39.9976	3110.81	39.9970	39.9970	3110.80	2001	2000	2000	2000
45.0	2828.84	44.9981	2828.05	44.9975	44.9975	2828.05	2001	2000	2001	2000
50.0	2611.17	49.9984	2610.45	49.9979	49.9979	2610.44	2000	2000	2000	2000
60.0	2309.88	59.9990	2309.24	59.9985	59.9986	2309.23	2001	2000	2000	2000
70.0	2128.89	69.9994	2128.30	69.9991	69.9991	2128.29	2001	2000	2001	2000
80.0	2031.24	79.9997	2030.68	79.9996	79.9996	2030.67	2000	2000	2000	2000
90.0	2000.40	90.0000	1999.84	90.0000	90.0000	1999.84	2000	2000	2000	2000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

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WEATHER DATA FOR TYPICAL COLD-MOIST MORNING SEA LEVEL INDEX OF REFRACTION: .0003226 SCALE HEIGHT: 6779.43 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	295927.73	-.3601	295848.90	-.4325	-.3075	295856.37	6861	5000	4630	5272
.5	227740.02	.2361	227682.76	.2124	.2318	227681.34	6050	5000	4908	4983
1.0	178953.96	.7983	178910.35	.7903	.8006	178910.18	5631	5000	4977	5007
1.5	144225.35	1.3401	144190.81	1.3377	1.3448	144191.32	5404	5000	4996	5012
2.0	119233.42	1.8691	119205.16	1.8690	1.8729	119205.87	5273	5000	5001	5008
2.5	100857.30	2.3900	100833.55	2.3907	2.3919	100834.24	5195	5000	5003	5003
3.0	86997.78	2.9056	86977.37	2.9066	2.9059	86977.96	5144	5000	5003	5001
3.5	76278.63	3.4175	76260.78	3.4187	3.4174	76261.25	5111	5000	5003	5000
4.0	67794.95	3.9269	67779.11	3.9281	3.9277	67779.48	5087	5000	5003	5001
4.5	60942.31	4.4345	60928.10	4.4356	4.4375	60928.39	5071	5000	5002	5003
5.0	55307.63	4.9407	55294.74	4.9417	4.9436	55294.96	5058	5000	5002	5003
6.0	46618.97	5.9503	46608.12	5.9511	5.9518	46608.26	5041	5000	5002	5001
7.0	40255.45	6.9573	40246.09	6.9579	6.9580	40246.19	5031	5000	5002	5001
8.0	35407.33	7.9626	35399.10	7.9631	7.9629	35399.19	5024	5000	5001	5000
9.0	31597.53	8.9668	31590.19	8.9672	8.9668	31590.27	5019	5000	5001	5000
10.0	28528.57	9.9702	28521.95	9.9705	9.9701	28522.03	5016	5000	5001	5000
12.0	23896.84	11.9753	23891.29	11.9755	11.9750	23891.37	5011	5000	5001	5000
14.0	20573.78	13.9790	20569.01	13.9791	13.9786	20569.08	5008	5000	5001	5000
16.0	18078.10	15.9818	18073.91	15.9818	15.9813	18073.97	5007	5000	5001	5000
18.0	16138.15	17.9840	16134.41	17.9839	17.9835	16134.46	5005	5000	5001	5000
20.0	14589.26	19.9858	14585.87	19.9856	19.9852	14585.92	5005	5000	5001	5000
25.0	11817.30	24.9890	11814.56	24.9888	24.9884	11814.60	5003	5000	5001	5000
30.0	9993.15	29.9912	9990.84	29.9909	29.9907	9990.87	5002	5000	5001	5000
35.0	8713.76	34.9928	8711.74	34.9925	34.9923	8711.77	5002	5000	5001	5000
40.0	7777.00	39.9941	7775.20	39.9938	39.9936	7775.23	5002	5000	5001	5000
45.0	7070.50	44.9950	7068.86	44.9948	44.9946	7068.89	5002	5000	5001	5000
50.0	6527.07	49.9959	6525.56	49.9956	49.9955	6525.58	5001	5000	5001	5000
60.0	5774.19	59.9972	5772.85	59.9970	59.9969	5772.87	5001	5000	5001	5000
70.0	5321.81	69.9983	5320.57	69.9981	69.9980	5320.59	5001	5000	5001	5000
80.0	5078.21	79.9992	5077.03	79.9991	79.9990	5077.05	5001	5000	5001	5000
90.0	5001.12	90.0000	4999.96	90.0000	90.0000	4999.98	5001	5000	5001	5000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

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WEATHER DATA FOR TYPICAL COLD-MOIST MORNING SEA LEVEL INDEX OF REFRACTION: .0003226 SCALE HEIGHT: 6779.43 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	412558.64	-.4624	412463.04	-.6029	-.3486	412481.75	13329	10000	8995	10819
.5	341946.29	.1417	341873.32	.0957	.1852	341877.17	12139	10000	9730	10259
1.0	286747.35	.7124	286689.29	.6998	.7409	286692.49	11440	10000	9940	10142
1.5	243436.04	1.2628	243388.41	1.2635	1.2838	243391.47	11009	10000	10006	10089
2.0	209329.66	1.8000	209289.63	1.8062	1.8151	209292.45	10732	10000	10025	10055
2.5	182288.06	2.3282	182253.74	2.3366	2.3383	182256.21	10547	10000	10029	10032
3.0	160633.61	2.8501	160603.69	2.8592	2.8566	160605.80	10421	10000	10028	10018
3.5	143087.57	3.3675	143061.13	3.3765	3.3724	143062.90	10332	10000	10025	10012
4.0	128692.14	3.8815	128668.49	3.8903	3.8870	128669.97	10267	10000	10022	10013
4.5	116734.77	4.3930	116713.41	4.4014	4.4014	116714.66	10219	10000	10019	10017
5.0	106685.26	4.9026	106665.80	4.9105	4.9117	106666.87	10182	10000	10017	10017
6.0	90817.82	5.9176	90801.33	5.9246	5.9237	90802.15	10132	10000	10013	10010
7.0	78926.78	6.9288	78912.49	6.9350	6.9331	78913.18	10099	10000	10010	10006
8.0	69726.22	7.9374	69713.63	7.9429	7.9406	69714.24	10077	10000	10008	10004
9.0	62417.71	8.9442	62406.45	8.9492	8.9467	62407.01	10062	10000	10007	10003
10.0	56484.00	9.9498	56473.82	9.9542	9.9517	56474.35	10051	10000	10006	10002
12.0	47457.44	11.9582	47448.90	11.9619	11.9595	47449.36	10036	10000	10005	10001
14.0	40934.77	13.9643	40927.41	13.9674	13.9653	40927.82	10026	10000	10004	10001
16.0	36013.63	15.9690	36007.16	15.9717	15.9697	36007.53	10021	10000	10003	10000
18.0	32176.49	17.9727	32170.71	17.9750	17.9732	32171.04	10016	10000	10003	10000
20.0	29106.06	19.9756	29100.84	19.9776	19.9760	29101.14	10013	10000	10003	10000
25.0	23598.24	24.9810	23594.01	24.9825	24.9812	23594.25	10009	10000	10002	10000
30.0	19965.96	29.9847	19962.38	29.9859	29.9848	19962.59	10006	10000	10002	10000
35.0	17415.22	34.9875	17412.09	34.9884	34.9874	17412.28	10005	10000	10002	10000
40.0	15546.07	39.9896	15543.28	39.9903	39.9895	15543.45	10004	10000	10002	10000
45.0	14135.71	44.9913	14133.18	44.9918	44.9912	14133.33	10003	10000	10002	10000
50.0	13050.60	49.9927	13048.26	49.9932	49.9926	13048.40	10003	10000	10002	10000
60.0	11546.58	59.9950	11544.51	59.9953	59.9949	11544.63	10002	10000	10002	10000
70.0	10642.75	69.9969	10640.84	69.9970	69.9968	10640.96	10002	10000	10002	10000
80.0	10155.83	79.9985	10154.01	79.9986	79.9984	10154.11	10002	10000	10002	10000
90.0	10001.75	90.0000	9999.96	90.0000	90.0000	10000.06	10002	10000	10002	10000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

COMPARISON OF GRADIENT (GMD), WHITE SANDS (CYBER) AND SPHERICAL SLAB (VARIAN) CORRECTION METHODS

BASED ON RESULTS OF GRADIENT REFRACTION SOLUTION FOR THE SAME MEASURED EL ANGLES AS USED IN JSC INTERNAL NOTE 75-FM-60

WEATHER DATA FOR TYPICAL COLD-MOIST MORNING SEA LEVEL INDEX OF REFRACTION: .0003226 SCALE HEIGHT: 6779.43 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	572003.46	-.5619	571897.98	-.8359	-.4182	571924.48	25598	20000	17280	21431
.5	499816.55	.0521	499734.69	-.0431	.1211	499741.70	23901	20000	19179	20600
1.0	440181.74	.6310	440115.51	.5999	.6795	440120.97	22831	20000	19767	20372
1.5	390273.53	1.1886	390218.36	1.1846	1.2252	390223.10	22118	20000	19977	20249
2.0	348256.22	1.7323	348209.23	1.7406	1.7598	348213.39	21625	20000	20054	20167
2.5	312744.26	2.2664	312703.52	2.2803	2.2865	312707.10	21274	20000	20080	20110
3.0	282613.86	2.7935	282578.02	2.8099	2.8083	282581.04	21017	20000	20084	20073
3.5	256934.80	3.3154	256902.88	3.3327	3.3275	256905.42	20827	20000	20080	20054
4.0	234936.50	3.8336	234907.79	3.8508	3.8459	234909.93	20682	20000	20073	20050
4.5	215985.00	4.3487	215958.94	4.3655	4.3644	215960.76	20570	20000	20066	20059
5.0	199561.46	4.8615	199537.63	4.8777	4.8778	199539.21	20482	20000	20059	20057
6.0	172686.28	5.8818	172665.96	5.8966	5.8937	172667.20	20356	20000	20047	20036
7.0	151786.74	6.8972	151769.06	6.9106	6.9064	151770.13	20272	20000	20038	20024
8.0	135180.22	7.9092	135164.58	7.9214	7.9166	135165.55	20214	20000	20031	20017
9.0	121728.50	8.9188	121714.49	8.9299	8.9250	121715.40	20172	20000	20026	20013
10.0	110645.89	9.9267	110633.21	9.9368	9.9320	110634.06	20141	20000	20022	20010
12.0	93528.87	11.9388	93518.21	11.9473	11.9428	93518.96	20100	20000	20016	20007
14.0	80982.61	13.9476	80973.40	13.9550	13.9508	80974.08	20074	20000	20012	20005
16.0	71428.86	15.9543	71420.76	15.9608	15.9570	71421.36	20057	20000	20010	20003
18.0	63932.05	17.9596	63924.81	17.9653	17.9619	63925.36	20045	20000	20008	20003
20.0	57906.08	19.9639	57899.53	19.9690	19.9659	57900.04	20036	20000	20007	20002
25.0	47042.71	24.9718	47037.40	24.9758	24.9733	47037.81	20023	20000	20005	20001
30.0	39845.70	29.9773	39841.21	29.9804	29.9784	39841.56	20016	20000	20004	20001
35.0	34778.47	34.9813	34774.55	34.9838	34.9822	34774.86	20012	20000	20004	20001
40.0	31059.20	39.9844	31055.70	39.9865	39.9851	31055.98	20009	20000	20003	20000
45.0	28249.78	44.9869	28246.60	44.9887	44.9875	28246.85	20007	20000	20003	20000
50.0	26086.57	49.9890	26083.63	49.9905	49.9895	26083.87	20005	20000	20003	20000
60.0	23086.32	59.9925	23083.72	59.9935	59.9928	23083.93	20004	20000	20002	20000
70.0	21282.18	69.9953	21279.78	69.9959	69.9954	21279.97	20003	20000	20002	20000
80.0	20309.96	79.9977	20307.68	79.9980	79.9978	20307.86	20002	20000	20002	20000
90.0	20002.25	90.0000	19999.99	90.0000	90.0000	20000.17	20002	20000	20002	20000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

COMPARISON OF GRADIENT (GMD), WHITE SANDS (CYBER) AND SPHERICAL SLAB (VARIAN) CORRECTION METHODS

BASED ON RESULTS OF GRADIENT REFRACTION SOLUTION FOR THE SAME MEASURED EL ANGLES AS USED IN JSC INTERNAL NOTE 75-FM-60

WEATHER DATA FOR TYPICAL COLD-MOIST MORNING SEA LEVEL INDEX OF REFRACTION: .0003226 SCALE HEIGHT: 6779.43 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H, METER	VAR H METER
0.0	877535.44	-.6634	877425.95	-1.2825	-.5218	877456.04	60085	50000	40598	52153
.5	804084.51	-.0342	803999.72	-.2557	.0115	804005.75	57443	50000	46923	50635
1.0	740766.02	.5558	740697.45	.4648	.5903	740702.34	55702	50000	48838	50440
1.5	685028.67	1.1221	684971.52	1.0861	1.1506	684975.95	54486	50000	49579	50337
2.0	635431.64	1.6726	635382.90	1.6630	1.6957	635386.87	53604	50000	49898	50253
2.5	591032.53	2.2123	590990.22	2.2160	2.2301	590993.67	52945	50000	50041	50181
3.0	551143.01	2.7442	551105.74	2.7548	2.7579	551108.66	52441	50000	50105	50130
3.5	515215.56	3.2702	515182.32	3.2845	3.2822	515184.76	52050	50000	50131	50106
4.0	482788.94	3.7918	482759.00	3.8079	3.8054	482761.05	51740	50000	50137	50113
4.5	453474.37	4.3099	453447.16	4.3267	4.3286	453448.91	51492	50000	50136	50146
5.0	426914.60	4.8254	426889.70	4.8423	4.8452	426891.20	51289	50000	50128	50146
6.0	380902.35	5.8501	380881.08	5.8665	5.8653	380882.26	50985	50000	50110	50098
7.0	342719.00	6.8691	342700.47	6.8845	6.8813	342701.50	50773	50000	50092	50070
8.0	310763.33	7.8840	310746.92	7.8982	7.8942	310747.87	50620	50000	50077	50053
9.0	283782.61	8.8960	283767.90	8.9092	8.9048	283768.80	50507	50000	50066	50042
10.0	260806.13	9.9059	260792.81	9.9181	9.9136	260793.66	50421	50000	50057	50034
12.0	223973.38	11.9211	223962.16	11.9316	11.9273	223962.93	50301	50000	50041	50023
14.0	195975.35	13.9323	195965.67	13.9415	13.9375	195966.36	50224	50000	50031	50015
16.0	174116.06	15.9409	174107.53	15.9490	15.9453	174108.16	50172	50000	50024	50011
18.0	156655.43	17.9477	156647.81	17.9549	17.9516	156648.37	50136	50000	50020	50009
20.0	142436.94	19.9532	142430.04	19.9597	19.9566	142430.56	50110	50000	50016	50007
25.0	116424.46	24.9634	116418.87	24.9685	24.9660	116419.30	50069	50000	50012	50005
30.0	98948.91	29.9704	98944.17	29.9745	29.9725	98944.54	50046	50000	50008	50003
35.0	86545.64	34.9756	86541.51	34.9790	34.9773	86541.83	50031	50000	50006	50001
40.0	77395.58	39.9796	77391.89	39.9824	39.9810	77392.19	50022	50000	50004	50001
45.0	70460.57	44.9829	70457.22	44.9853	44.9841	70457.48	50016	50000	50004	50000
50.0	65108.19	49.9856	65105.09	49.9876	49.9866	65105.34	50012	50000	50003	50000
60.0	57668.24	59.9901	57665.51	59.9915	59.9908	57665.72	50007	50000	50003	50000
70.0	53185.88	69.9938	53183.36	69.9946	69.9942	53183.56	50004	50000	50002	50000
80.0	50768.01	79.9970	50765.61	79.9974	79.9972	50765.80	50003	50000	50002	50000
90.0	50002.38	90.0000	50000.00	90.0000	90.0000	50000.19	50002	50000	50002	50000

**** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

COMPARISON OF GRADIENT (GMD), WHITE SANDS (CYBER) AND SPHERICAL SLAB (VARIAN) CORRECTION METHODS

BASED ON RESULTS OF GRADIENT REFRACTION SOLUTION FOR THE SAME MEASURED EL ANGLES AS USED IN JSC INTERNAL NOTE 75-FM-60

WEATHER DATA FOR TYPICAL COLD-MOIST MORNING SEA LEVEL INDEX OF REFRACTION: .0003226 SCALE HEIGHT: 6779.43 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R, MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	1216581.21	-.7170	1216470.33	-1.7780	-.5806	1216501.74	114990	100000	77806	102854
.5	1142531.06	-.0769	1142445.52	-.4336	-.0513	1142451.95	111330	100000	93007	100503
1.0	1077440.99	.5207	1077371.97	.3669	.5420	1077376.20	108879	100000	97164	100395
1.5	1018814.72	1.0924	1018757.28	1.0212	1.1126	1018761.34	107140	100000	98764	100354
2.0	965291.67	1.6471	965242.75	1.6152	1.6647	965246.50	105855	100000	99478	100291
2.5	916066.17	2.1900	916023.74	2.1785	2.2041	916027.05	104881	100000	99826	100222
3.0	870554.63	2.7244	870517.27	2.7240	2.7356	870520.10	104122	100000	99999	100166
3.5	828360.50	3.2524	828327.20	3.2583	3.2628	828329.58	103522	100000	100088	100146
4.0	789167.33	3.7757	789137.34	3.7851	3.7885	789139.35	103039	100000	100132	100173
4.5	752706.92	4.2952	752679.67	4.3066	4.3140	752681.39	102645	100000	100152	100243
5.0	718748.24	4.8118	718723.30	4.8242	4.8322	718724.78	102320	100000	100157	100251
6.0	657566.39	5.8384	657545.10	5.8515	5.8543	657546.26	101818	100000	100149	100177
7.0	604261.28	6.8588	604242.73	6.8715	6.8717	604243.74	101458	100000	100134	100132
8.0	557678.14	7.8748	557661.72	7.8869	7.8858	557662.65	101192	100000	100118	100104
9.0	516813.62	8.8877	516798.91	8.8991	8.8973	516799.79	100986	100000	100101	100082
10.0	480861.80	9.8984	480848.47	9.9090	9.9068	480849.31	100830	100000	100090	100069
12.0	420899.89	11.9148	420888.67	11.9240	11.9216	420889.43	100604	100000	100067	100047
14.0	373347.66	13.9268	373337.97	13.9350	13.9326	373338.65	100457	100000	100052	100035
16.0	335024.92	15.9361	335016.39	15.9433	15.9411	335017.01	100355	100000	100041	100026
18.0	303680.02	17.9434	303672.40	17.9499	17.9478	303672.96	100283	100000	100035	100022
20.0	277677.73	19.9494	277670.83	19.9552	19.9533	277671.35	100228	100000	100027	100016
25.0	229084.02	24.9603	229078.43	24.9649	24.9634	229078.85	100143	100000	100018	100010
30.0	195752.11	29.9679	195747.37	29.9717	29.9703	195747.74	100095	100000	100012	100006
35.0	171793.66	34.9735	171789.53	34.9766	34.9755	171789.85	100065	100000	100009	100004
40.0	153973.74	39.9779	153970.05	39.9805	39.9795	153970.34	100046	100000	100007	100003
45.0	140392.51	44.9814	140389.16	44.9836	44.9828	140389.42	100033	100000	100005	100002
50.0	129870.85	49.9844	129867.75	49.9862	49.9856	129867.99	100025	100000	100005	100002
60.0	115189.05	59.9893	115186.31	59.9905	59.9901	115186.53	100013	100000	100003	100001
70.0	106316.02	69.9932	106313.50	69.9940	69.9937	106313.70	100006	100000	100003	100000
80.0	101521.67	79.9967	101519.26	79.9971	79.9970	101519.45	100003	100000	100002	100000
90.0	100002.38	90.0000	100000.00	90.0000	90.0000	100000.19	100002	100000	100002	100000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

APPENDIX G

TABULATED REFRACTION COMPARISON DATA FOR EDWARDS TYPICAL WARM MOIST MORNING

TABLE G-I

WEATHER DATA FOR TYPICAL WARM MOIST MORNING

ALTITUDE (FT)	TEMPERATURE (DEG C)	DEW POINT (DEG C)	PRESSURE (MB)	N X 10E6
2316	17.00001	15.84997	929.00000	329.30969
3000	29.00000	-.15002	903.26001	257.02301
4000	27.00000	-16.15002	891.03003	237.67468
5000	24.50000	-17.15002	857.80005	230.47379
6000	22.00000	-18.15002	819.53003	221.86047
7000	19.50000	-19.15002	794.59998	216.67038
8000	17.00000	-20.15002	768.16003	211.01862
9000	14.50000	-21.15002	739.39001	204.66995
10000	12.00000	-22.15002	713.06006	198.90247
11000	9.50000	-23.15002	688.07996	193.43057
12000	7.00000	-25.15002	663.22998	187.56149
13000	4.50000	-27.15002	639.75000	182.07138
14000	2.00001	-29.15002	617.23010	176.84204
15000	-.50000	-31.15002	594.35999	171.49615
16000	-3.00000	-33.15002	572.38000	166.37622
17000	-5.50000	-36.15002	551.87000	161.49234
18000	-8.00000	-39.15002	531.03003	156.53363
19000	-10.50000	-42.15002	510.69000	151.71918
20000	-13.00000	-45.15002	491.85999	147.33475
21000	-15.70001	-48.15002	473.03998	143.03632
22000	-18.40002	-51.15002	454.40997	138.74869
23000	-21.30002	-54.15002	437.02002	134.89230
24000	-24.00003	-57.15002	420.14001	131.02570
25000	-26.70001	-60.15002	403.20001	127.07535
26000	-29.50003	-64.15002	387.12000	123.36671
27000	-32.30000	-68.14999	372.11011	119.93466
28000	-35.10002	-72.15001	356.70007	116.30334
29000	-37.90002	-76.15002	341.96997	112.81746
30000	-40.70001	-80.15002	328.31000	109.60959
31000	-40.67321	-78.92619	328.18799	109.49875
32000	-43.26289	-78.77321	315.28833	106.24097
33000	-47.19596	-79.23215	296.06165	101.44191
34000	-51.19937	-79.84407	276.95868	96.70723
35000	-54.00003	-80.15002	264.42999	93.64259
36000	-56.30975	-80.15002	255.89999	91.58688
37000	-59.35925	-80.15002	245.22552	88.96097
38000	-62.65390	-80.15002	233.50607	85.99347
39000	-65.69904	-80.15002	221.84106	82.91298
40000	-68.00003	-80.15002	211.32999	79.94809
41000	-69.18581	-80.15002	201.81140	76.86771
42000	-69.44051	-80.15002	192.46701	73.42751
43000	-69.10233	-80.15002	183.41089	69.83629
44000	-68.50945	-80.15002	174.75720	66.30289
45000	-68.00003	-80.15002	166.62000	63.03609
46000	-67.35915	-80.15002	158.83591	59.92341
47000	-66.26350	-80.15002	151.21689	56.76656
48000	-64.88873	-80.15002	143.84003	53.64563
49000	-63.41046	-80.15002	136.78241	50.64070
50000	-62.00433	-80.15002	130.12112	47.83187

TABLE G-I -- Continued

WEATHER DATA FOR TYPICAL WARM MOIST MORNING

ALTITUDE (FT)	TEMPERATURE (DEG C)	DEW POINT (DEG C)	PRESSURE (MB)	N X 10E6
51000	-60.56895	-80.15002	123.71893	45.17155
52000	-58.98966	-80.15002	117.44495	42.58508
53000	-57.42764	-80.15002	111.38992	40.11436
54000	-56.04404	-80.15002	105.64471	37.80131
55000	-55.00003	-80.15002	100.30000	35.68780
56000	-54.47746	-80.15002	95.31410	33.79884
57000	-54.41688	-80.15002	90.58319	32.10184
58000	-54.61759	-80.15002	86.10529	30.55256
59000	-54.87888	-80.15002	81.87820	29.10661
60000	-55.00003	-80.15002	77.89999	27.71970
61000	-54.98045	-80.15002	74.13089	26.37768
62000	-54.96028	-80.15002	70.53699	25.09793
63000	-54.94990	-80.15002	67.12457	23.88339
64000	-54.95969	-80.15002	63.90015	22.73705
65000	-55.00003	-80.15002	60.87000	21.66182
66000	-55.07311	-80.15002	58.00195	20.64641
67000	-55.14839	-80.15002	55.26201	19.67670
68000	-55.18713	-80.15002	52.65412	18.75158
69000	-55.15058	-80.15002	50.18214	17.86984
70000	-55.00003	-80.15002	47.85000	17.03036
71000	-54.62611	-80.15002	45.62428	16.21456
72000	-54.02283	-80.15002	43.47842	15.41321
73000	-53.30652	-80.15002	41.42638	14.63907
74000	-52.59348	-80.15002	39.48225	13.90495
75000	-52.00003	-80.15002	37.66000	13.22361
76000	-51.53118	-80.15002	35.93859	12.59022
77000	-51.10735	-80.15002	34.29008	11.99045
78000	-50.71793	-80.15002	32.71828	11.42289
79000	-50.35236	-80.15002	31.22698	10.88610
80000	-50.00003	-80.15002	29.82000	10.37866
81000	-49.62761	-80.15002	28.47564	9.89296
82000	-49.20585	-80.15002	27.17604	9.42399
83000	-48.73029	-80.15002	25.93060	8.97419
84000	-48.19650	-80.15002	24.74878	8.54601
85000	-47.60004	-80.15002	23.64000	8.14192
86000	-46.86880	-80.15002	22.58916	7.75574
87000	-46.01745	-80.15002	21.57758	7.38245
88000	-45.17173	-80.15002	20.60943	7.02622
89000	-44.45734	-80.15002	19.68884	6.69122
90000	-44.00003	-80.15002	18.82000	6.38161
91000	-43.87155	-80.15002	18.02932	6.10960
92000	-43.63983	-80.15002	17.15881	5.81004
93000	-42.94996	-80.15002	16.22529	5.47901
94000	-42.11295	-80.15002	15.44332	5.19646
95000	-41.53740	-80.15002	14.95721	5.01962
96000	-41.17400	-80.15002	14.63868	4.90530
97000	-40.48238	-80.15002	14.12607	4.72159
98000	-39.56448	-80.15002	13.48358	4.49147
99000	-38.53429	-80.15002	12.78299	4.24069
100000	-37.50578	-80.15002	12.09601	3.99496

COMPARISON OF GRADIENT (GMD), WHITE SANDS (CYBER) AND SPHERICAL SLAB (VARIAN) CORRECTION METHODS

BASED ON RESULTS OF GRADIENT REFRACTION SOLUTION FOR THE SAME MEASURED EL ANGLES AS USED IN JSC INTERNAL NOTE 75-FM-60

WEATHER DATA FOR TYPICAL WARM-MOIST MORNING SEA LEVEL INDEX OF REFRACTION: .0003661 SCALE HEIGHT: 5977.06 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	143171.41	-.2425	143122.44	*******	-.2467	143115.05	1607	1000	*******	989
.5	79089.58	.3696	79063.52	*******	.3638	79060.07	1180	1000	*******	992
1.0	50129.67	.9184	50113.34	*******	.9180	50112.09	1072	1000	*******	1000
1.5	35764.69	1.4422	35753.09	*******	1.4426	35752.49	1036	1000	*******	1000
2.0	27567.91	1.9558	27558.98	*******	1.9556	27558.59	1022	1000	*******	1000
2.5	22355.21	2.4644	22347.98	*******	2.4636	22347.69	1014	1000	*******	1000
3.0	18772.98	2.9703	18766.91	*******	2.9690	18766.67	1010	1000	*******	1000
3.5	16168.62	3.4745	16163.39	*******	3.4732	16163.18	1007	1000	*******	1000
4.0	14193.46	3.9778	14188.87	*******	3.9768	14188.68	1006	1000	*******	1000
4.5	12645.80	4.4803	12641.71	*******	4.4802	12641.54	1005	1000	*******	1000
5.0	11401.27	4.9824	11397.59	*******	4.9815	11397.43	1004	1000	*******	1000
6.0	9525.53	5.9855	9522.45	*******	5.9845	9522.31	1003	1000	*******	1000
7.0	8180.04	6.9877	8177.40	*******	6.9866	8177.28	1002	1000	*******	1000
8.0	7168.55	7.9894	7166.23	*******	7.9883	7166.13	1002	1000	*******	1000
9.0	6381.06	8.9907	6379.00	*******	8.9896	6378.90	1001	1000	*******	1000
10.0	5750.74	9.9917	5748.88	*******	9.9906	5748.80	1001	1000	*******	1000
12.0	4805.58	11.9933	4804.03	*******	11.9922	4803.96	1001	1000	*******	1000
14.0	4131.28	13.9944	4129.95	*******	13.9934	4129.89	1001	1000	*******	1000
16.0	3626.63	15.9953	3625.46	*******	15.9942	3625.41	1001	1000	*******	1000
18.0	3235.27	17.9959	3234.22	*******	17.9949	3234.18	1000	1000	*******	1000
20.0	2923.45	19.9964	2922.50	*******	19.9954	2922.46	1000	1000	*******	1000
25.0	2366.24	24.9974	2365.48	*******	24.9964	2365.44	1000	1000	*******	1000
30.0	2000.11	29.9981	1999.47	*******	29.9971	1999.44	1000	1000	*******	1000
35.0	1743.69	34.9985	1743.13	*******	34.9976	1743.10	1000	1000	*******	1000
40.0	1556.04	39.9988	1555.53	*******	39.9980	1555.51	1000	1000	*******	1000
45.0	1414.57	44.9991	1414.11	*******	44.9983	1414.09	1000	1000	*******	1000
50.0	1305.59	49.9993	1305.17	*******	49.9986	1305.15	1000	1000	*******	1000
60.0	1154.91	59.9995	1154.55	*******	59.9990	1154.52	1000	1000	*******	1000
70.0	1064.40	69.9997	1064.07	*******	69.9994	1064.04	1000	1000	*******	1000
80.0	1015.66	79.9999	1015.34	*******	79.9997	1015.32	1000	1000	*******	1000
90.0	1000.24	90.0000	999.92	*******	90.0000	999.90	1000	1000	*******	1000

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COMPARISON OF GRADIENT (GMD), WHITE SANDS (CYBER) AND SPHERICAL SLAB (VARIAN) CORRECTION METHODS

BASED ON RESULTS OF GRADIENT REFRACTION SOLUTION FOR THE SAME MEASURED EL ANGLES AS USED IN JSC INTERNAL NOTE 75-FM-60

WEATHER DATA FOR TYPICAL WARM-MOIST MORNING SEA LEVEL INDEX OF REFRACTION: .0003661 SCALE HEIGHT: 5977.06 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	199864.31	-.3238	199801.63	*******	-.3321	199797.50	3131	2000	*******	1971
.5	129740.23	.3011	129702.25	*******	.2805	129694.78	2451	2000	*******	1953
1.0	90237.98	.8653	90212.29	*******	.8585	90208.35	2213	2000	*******	1989
1.5	67319.16	1.4008	67300.22	*******	1.3974	67297.80	2117	2000	*******	1996
2.0	53066.09	1.9224	53051.24	*******	1.9191	53049.51	2072	2000	*******	1997
2.5	43563.99	2.4367	43551.84	*******	2.4328	43550.46	2049	2000	*******	1997
3.0	36851.82	2.9467	36841.56	*******	2.9424	36840.40	2035	2000	*******	1997
3.5	31887.59	3.4541	31878.72	*******	3.4500	31877.70	2026	2000	*******	1998
4.0	28080.06	3.9597	28072.26	*******	3.9566	28071.34	2020	2000	*******	1998
4.5	25073.25	4.4642	25066.28	*******	4.4627	25065.45	2016	2000	*******	1999
5.0	22641.94	4.9678	22635.65	*******	4.9656	22634.89	2013	2000	*******	1999
6.0	18956.62	5.9732	18951.36	*******	5.9710	18950.70	2009	2000	*******	1999
7.0	16300.10	6.9771	16295.58	*******	6.9749	16295.01	2007	2000	*******	1999
8.0	14297.04	7.9801	14293.07	*******	7.9780	14292.58	2005	2000	*******	1999
9.0	12733.73	8.9824	12730.19	*******	8.9804	12729.75	2004	2000	*******	1999
10.0	11480.75	9.9843	11477.56	*******	9.9823	11477.17	2004	2000	*******	2000
12.0	9599.04	11.9871	9596.38	*******	11.9853	9596.05	2003	2000	*******	2000
14.0	8254.89	13.9891	8252.60	*******	13.9874	8252.32	2002	2000	*******	2000
16.0	7248.13	15.9906	7246.12	*******	15.9891	7245.87	2002	2000	*******	2000
18.0	6467.07	17.9918	6465.28	*******	17.9903	6465.06	2001	2000	*******	2000
20.0	5844.24	19.9928	5842.62	*******	19.9914	5842.42	2001	2000	*******	2000
25.0	4731.13	24.9945	4729.82	*******	24.9933	4729.65	2001	2000	*******	2000
30.0	3999.61	29.9957	3998.50	*******	29.9945	3998.36	2001	2000	*******	2000
35.0	3487.03	34.9965	3486.06	*******	34.9955	3485.94	2001	2000	*******	2000
40.0	3111.71	39.9972	3110.84	*******	39.9962	3110.74	2001	2000	*******	2000
45.0	2828.85	44.9977	2828.07	*******	44.9969	2827.97	2001	2000	*******	2000
50.0	2611.19	49.9981	2610.47	*******	49.9974	2610.38	2001	2000	*******	2000
60.0	2309.88	59.9988	2309.25	*******	59.9982	2309.16	2001	2000	*******	2000
70.0	2128.88	69.9992	2128.30	*******	69.9989	2128.22	2001	2000	*******	2000
80.0	2031.25	79.9996	2030.69	*******	79.9994	2030.62	2000	2000	*******	2000
90.0	2000.41	90.0000	1999.86	*******	90.0000	1999.78	2000	2000	*******	2000

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WEATHER DATA FOR TYPICAL WARM-MOIST MORNING SEA LEVEL INDEX OF REFRACTION: .0003661 SCALE HEIGHT: 5977.06 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	308341.52	-.4548	308256.34	*******	-.4187	308263.75	7449	5000	*******	5194
.5	232911.85	.1849	232853.31	*******	.1462	232844.77	6282	5000	*******	4843
1.0	181402.44	.7657	181358.90	*******	.7424	181353.43	5743	5000	*******	4926
1.5	145517.41	1.3166	145483.30	*******	1.3019	145479.77	5467	5000	*******	4963
2.0	119973.43	1.8509	119945.67	*******	1.8388	119943.14	5313	5000	*******	4974
2.5	101310.40	2.3752	101287.14	*******	2.3634	101285.11	5222	5000	*******	4979
3.0	87290.83	2.8932	87270.88	*******	2.8814	87269.11	5164	5000	*******	4982
3.5	76477.23	3.4068	76459.80	*******	3.3961	76458.20	5125	5000	*******	4986
4.0	67934.84	3.9176	67919.40	*******	3.9092	67917.91	5099	5000	*******	4990
4.5	61044.09	4.4262	61030.24	*******	4.4216	61028.86	5080	5000	*******	4995
5.0	55383.65	4.9332	55371.10	*******	4.9292	55369.80	5065	5000	*******	4996
6.0	46664.46	5.9440	46653.89	*******	5.9395	46652.76	5046	5000	*******	4996
7.0	40284.56	6.9519	40275.45	*******	6.9474	40274.47	5035	5000	*******	4997
8.0	35427.01	7.9579	35419.00	*******	7.9535	35418.14	5027	5000	*******	4997
9.0	31611.36	8.9627	31604.22	*******	8.9585	31603.46	5021	5000	*******	4998
10.0	28538.66	9.9665	28532.22	*******	9.9625	28531.54	5018	5000	*******	4998
12.0	23902.61	11.9722	23897.22	*******	11.9687	23896.66	5012	5000	*******	4998
14.0	20577.36	13.9764	20572.72	*******	13.9732	20572.24	5009	5000	*******	4999
16.0	18080.45	15.9795	18076.38	*******	15.9766	18075.96	5007	5000	*******	4999
18.0	16139.75	17.9820	16136.12	*******	17.9793	16135.74	5006	5000	*******	4999
20.0	14590.41	19.9840	14587.12	*******	19.9815	14586.78	5005	5000	*******	4999
25.0	11817.83	24.9876	11815.16	*******	24.9855	11814.89	5003	5000	*******	4999
30.0	9993.42	29.9901	9991.17	*******	29.9883	9990.94	5003	5000	*******	5000
35.0	8713.91	34.9919	8711.94	*******	34.9904	8711.74	5002	5000	*******	5000
40.0	7777.08	39.9933	7775.32	*******	39.9919	7775.15	5002	5000	*******	5000
45.0	7070.53	44.9944	7068.94	*******	44.9932	7068.78	5002	5000	*******	5000
50.0	6527.07	49.9954	6525.61	*******	49.9943	6525.46	5001	5000	*******	5000
60.0	5774.17	59.9969	5772.87	*******	59.9961	5772.73	5001	5000	*******	5000
70.0	5321.78	69.9981	5320.58	*******	69.9975	5320.46	5001	5000	*******	5000
80.0	5078.17	79.9991	5077.03	*******	79.9988	5076.91	5001	5000	*******	5000
90.0	5001.08	90.0000	4999.96	*******	90.0000	4999.84	5001	5000	*******	5000

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INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	426524.78	-.5706	426421.74	*******	-.4901	426442.66	14246	10000	*******	10600
.5	348571.75	.0801	348496.78	*******	.0702	348494.13	12554	10000	*******	9940
1.0	290413.89	.6707	290355.34	*******	.6583	290353.67	11669	10000	*******	9937
1.5	245674.49	1.2313	245626.83	*******	1.2214	245626.25	11153	10000	*******	9957
2.0	210777.38	1.7747	210737.47	*******	1.7651	210737.41	10830	10000	*******	9965
2.5	183263.01	2.3071	183228.87	*******	2.2965	183228.93	10618	10000	*******	9966
3.0	161312.45	2.8320	161282.73	*******	2.8207	161282.74	10474	10000	*******	9968
3.5	143574.42	3.3517	143548.17	*******	3.3412	143548.09	10373	10000	*******	9974
4.0	129050.04	3.8675	129026.58	*******	3.8599	129026.40	10299	10000	*******	9983
4.5	117004.25	4.3805	116983.07	*******	4.3781	116982.84	10245	10000	*******	9995
5.0	106892.06	4.8912	106872.78	*******	4.8909	106872.50	10204	10000	*******	9999
6.0	90946.42	5.9081	90930.08	*******	5.9059	90929.79	10147	10000	*******	9997
7.0	79011.34	6.9206	78997.19	*******	6.9177	78996.93	10110	10000	*******	9996
8.0	69784.53	7.9302	69772.05	*******	7.9270	69771.85	10086	10000	*******	9996
9.0	62459.34	8.9378	62448.19	*******	8.9346	62448.04	10069	10000	*******	9996
10.0	56514.71	9.9440	56504.63	*******	9.9408	56504.52	10056	10000	*******	9997
12.0	47475.40	11.9534	47466.95	*******	11.9504	47466.88	10039	10000	*******	9997
14.0	40946.09	13.9603	40938.80	*******	13.9574	40938.76	10029	10000	*******	9998
16.0	36021.18	15.9655	36014.77	*******	15.9628	36014.74	10023	10000	*******	9998
18.0	32181.73	17.9695	32176.01	*******	17.9671	32175.99	10018	10000	*******	9999
20.0	29109.87	19.9728	29104.69	*******	19.9706	29104.68	10015	10000	*******	9999
25.0	23600.08	24.9789	23595.89	*******	24.9770	23595.88	10010	10000	*******	9999
30.0	19966.96	29.9830	19963.41	*******	29.9814	19963.41	10007	10000	*******	9999
35.0	17415.81	34.9860	17412.72	*******	34.9846	17412.71	10005	10000	*******	10000
40.0	15546.43	39.9884	15543.67	*******	39.9872	15543.67	10004	10000	*******	10000
45.0	14135.92	44.9903	14133.41	*******	44.9892	14133.41	10003	10000	*******	10000
50.0	13050.73	49.9919	13048.42	*******	49.9910	13048.41	10003	10000	*******	10000
60.0	11546.61	59.9945	11544.57	*******	59.9938	11544.56	10002	10000	*******	10000
70.0	10642.75	69.9965	10640.86	*******	69.9961	10640.85	10002	10000	*******	10000
80.0	10155.80	79.9983	10154.01	*******	79.9981	10154.00	10002	10000	*******	10000
90.0	10001.72	90.0000	9999.95	*******	90.0000	9999.94	10002	10000	*******	10000

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INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	587895.64	-.6874	587780.17	*******	-.5921	587812.09	27037	20000	*******	20978
.5	508308.90	-.0244	508222.99	*******	-.0288	508226.08	24643	20000	*******	19962
1.0	445557.95	.5754	445489.43	*******	.5707	445491.91	23296	20000	*******	19964
1.5	394006.21	1.1440	393949.40	*******	1.1429	393952.49	22444	20000	*******	19993
2.0	350965.81	1.6947	350917.50	*******	1.6943	350920.72	21867	20000	*******	19998
2.5	314761.72	2.2338	314719.85	*******	2.2322	314722.86	21460	20000	*******	19992
3.0	284143.21	2.7647	284106.38	*******	2.7620	284109.02	21165	20000	*******	19987
3.5	258112.04	3.2898	258079.24	*******	3.2876	258081.51	20946	20000	*******	19991
4.0	235854.91	3.8104	235825.39	*******	3.8116	235827.35	20779	20000	*******	20005
4.5	216710.82	4.3276	216684.02	*******	4.3351	216685.74	20651	20000	*******	20029
5.0	200141.79	4.8421	200117.29	*******	4.8522	200118.80	20551	20000	*******	20035
6.0	173070.17	5.8653	173049.27	*******	5.8720	173050.53	20406	20000	*******	20020
7.0	152050.76	6.8828	152032.58	*******	6.8875	152033.71	20310	20000	*******	20013
8.0	135368.23	7.8965	135352.15	*******	7.9000	135353.22	20244	20000	*******	20008
9.0	121866.12	8.9075	121851.71	*******	8.9102	121852.72	20196	20000	*******	20006
10.0	110749.42	9.9164	110736.38	*******	9.9186	110737.33	20161	20000	*******	20004
12.0	93591.13	11.9302	93580.16	*******	11.9317	93581.02	20114	20000	*******	20003
14.0	81022.63	13.9402	81013.16	*******	13.9413	81013.93	20084	20000	*******	20002
16.0	71455.96	15.9479	71447.63	*******	15.9488	71448.32	20065	20000	*******	20001
18.0	63951.13	17.9540	63943.69	*******	17.9546	63944.31	20051	20000	*******	20001
20.0	57920.05	19.9588	57913.31	*******	19.9594	57913.89	20041	20000	*******	20001
25.0	47049.71	24.9679	47044.25	*******	24.9682	47044.72	20026	20000	*******	20000
30.0	39849.62	29.9741	39844.99	*******	29.9743	39845.40	20018	20000	*******	20000
35.0	34780.87	34.9786	34776.83	*******	34.9787	34777.19	20013	20000	*******	20000
40.0	31060.73	39.9822	31057.13	*******	39.9823	31057.45	20010	20000	*******	20000
45.0	28250.77	44.9851	28247.50	*******	44.9851	28247.79	20007	20000	*******	20000
50.0	26087.23	49.9875	26084.21	*******	49.9875	26084.48	20006	20000	*******	20000
60.0	23086.63	59.9915	23083.96	*******	59.9914	23084.19	20004	20000	*******	20000
70.0	21282.33	69.9946	21279.87	*******	69.9946	21280.08	20003	20000	*******	20000
80.0	20310.04	79.9974	20307.69	*******	79.9974	20307.90	20002	20000	*******	20000
90.0	20002.31	90.0000	19999.99	*******	90.0000	20000.20	20002	20000	*******	20000

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E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	895393.45	-.8089	895272.60	*******	-.7212	895309.54	62543	50000	*******	51362
.5	814515.39	-.1268	814425.79	*******	-.1698	814432.15	58845	50000	*******	49393
1.0	748004.85	.4858	747933.48	*******	.4607	747935.44	56664	50000	*******	49674
1.5	690508.53	1.0641	690449.36	*******	1.0543	690452.51	55214	50000	*******	49881
2.0	639746.99	1.6227	639696.64	*******	1.6203	639700.16	54181	50000	*******	49972
2.5	594501.71	2.1683	594458.04	*******	2.1685	594461.43	53415	50000	*******	50000
3.0	553967.63	2.7049	553929.17	*******	2.7061	553932.22	52831	50000	*******	50010
3.5	517537.31	3.2347	517503.02	*******	3.2380	517505.70	52377	50000	*******	50029
4.0	484713.82	3.7594	484682.94	*******	3.7676	484685.28	52018	50000	*******	50068
4.5	455080.59	4.2803	455052.53	*******	4.2967	455054.61	51730	50000	*******	50129
5.0	428263.03	4.7980	428237.34	*******	4.8177	428239.21	51496	50000	*******	50145
6.0	381870.44	5.8265	381848.50	*******	5.8421	381850.08	51143	50000	*******	50101
7.0	343430.44	6.8484	343411.33	*******	6.8613	343412.76	50897	50000	*******	50075
8.0	311296.02	7.8656	311279.11	*******	7.8767	311280.45	50719	50000	*******	50058
9.0	284190.37	8.8795	284175.21	*******	8.8892	284176.48	50588	50000	*******	50046
10.0	261121.44	9.8909	261107.70	*******	9.8995	261108.91	50489	50000	*******	50039
12.0	224173.40	11.9085	224161.84	*******	11.9156	224162.91	50349	50000	*******	50026
14.0	196107.96	13.9215	196097.97	*******	13.9275	196098.94	50260	50000	*******	50018
16.0	174207.80	15.9315	174199.01	*******	15.9367	174199.87	50200	50000	*******	50014
18.0	156721.01	17.9393	156713.16	*******	17.9439	156713.95	50158	50000	*******	50011
20.0	142485.38	19.9457	142478.27	*******	19.9498	142478.99	50127	50000	*******	50009
25.0	116449.21	24.9575	116443.45	*******	24.9607	116444.04	50080	50000	*******	50006
30.0	98962.82	29.9657	98957.94	*******	29.9682	98958.45	50053	50000	*******	50003
35.0	86554.10	34.9716	86549.83	*******	34.9737	86550.28	50036	50000	*******	50002
40.0	77400.92	39.9763	77397.11	*******	39.9780	77397.51	50026	50000	*******	50001
45.0	70463.99	44.9801	70460.53	*******	44.9816	70460.90	50019	50000	*******	50001
50.0	65110.44	49.9834	65107.25	*******	49.9845	65107.58	50014	50000	*******	50000
60.0	57669.22	59.9886	57666.40	*******	59.9893	57666.69	50008	50000	*******	50000
70.0	53186.28	69.9928	53183.69	*******	69.9933	53183.96	50004	50000	*******	50000
80.0	50768.16	79.9965	50765.68	*******	79.9967	50765.94	50003	50000	*******	50000
90.0	50002.45	90.0000	50000.00	*******	90.0000	50000.26	50002	50000	*******	50000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

COMPARISON OF GRADIENT (GMD), WHITE SANDS (CYBER) AND SPHERICAL SLAB (VARIAN) CORRECTION METHODS

BASED ON RESULTS OF GRADIENT REFRACTION SOLUTION FOR THE SAME MEASURED EL ANGLES AS USED IN JSC INTERNAL NOTE 75-FM-60

WEATHER DATA FOR TYPICAL WARM-MOIST MORNING SEA LEVEL INDEX OF REFRACTION: .0003661 SCALE HEIGHT: 5977.06 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	1235378.72	-.8736	1235255.79	*******	-.7919	1235294.66	118538	100000	*******	101739
.5	1153895.09	-.1777	1153804.39	*******	-.2455	1153811.80	113438	100000	*******	98657
1.0	1085594.94	.4438	1085522.92	*******	.4051	1085524.03	110378	100000	*******	99277
1.5	1025191.00	1.0285	1025131.42	*******	1.0120	1025134.16	108309	100000	*******	99708
2.0	970466.99	1.5919	970416.37	*******	1.5867	970419.69	106805	100000	*******	99911
2.5	920359.09	2.1413	920315.23	*******	2.1408	920318.52	105673	100000	*******	99992
3.0	874154.51	2.6808	874115.92	*******	2.6825	874118.91	104792	100000	*******	100025
3.5	831413.12	3.2131	831378.74	*******	3.2178	831381.37	104096	100000	*******	100066
4.0	791774.05	3.7398	791743.09	*******	3.7502	791745.41	103536	100000	*******	100140
4.5	754948.53	4.2623	754920.41	*******	4.2818	754922.48	103079	100000	*******	100252
5.0	720679.43	4.7815	720653.70	*******	4.8046	720655.56	102700	100000	*******	100284
6.0	659029.73	5.8122	659007.77	*******	5.8310	659009.34	102117	100000	*******	100209
7.0	605388.02	6.8358	605368.89	*******	6.8517	605370.32	101698	100000	*******	100162
8.0	558555.31	7.8544	558538.38	*******	7.8682	558539.72	101387	100000	*******	100131
9.0	517509.69	8.8694	517494.52	*******	8.8816	517495.79	101149	100000	*******	100106
10.0	481418.14	9.8817	481404.39	*******	9.8927	481405.59	100967	100000	*******	100089
12.0	421269.81	11.9008	421258.25	*******	11.9099	421259.32	100704	100000	*******	100063
14.0	373602.20	13.9148	373592.22	*******	13.9226	373593.18	100532	100000	*******	100047
16.0	335206.20	15.9256	335197.41	*******	15.9324	335198.28	100413	100000	*******	100036
18.0	303812.16	17.9341	303804.30	*******	17.9401	303805.08	100330	100000	*******	100030
20.0	277777.14	19.9410	277770.03	*******	19.9464	277770.75	100266	100000	*******	100023
25.0	229135.95	24.9538	229130.18	*******	24.9580	229130.78	100166	100000	*******	100014
30.0	195781.76	29.9626	195776.88	*******	29.9660	195777.39	100110	100000	*******	100009
35.0	171811.80	34.9691	171807.54	*******	34.9719	171807.98	100076	100000	*******	100006
40.0	153985.23	39.9742	153981.42	*******	39.9766	153981.82	100054	100000	*******	100004
45.0	140399.90	44.9784	140396.44	*******	44.9803	140396.80	100038	100000	*******	100003
50.0	129875.68	49.9819	129872.49	*******	49.9835	129872.83	100028	100000	*******	100003
60.0	115191.12	59.9875	115188.30	*******	59.9886	115188.59	100014	100000	*******	100001
70.0	106316.83	69.9921	106314.23	*******	69.9928	106314.50	100007	100000	*******	100001
80.0	101521.90	79.9962	101519.42	*******	79.9965	101519.68	100004	100000	*******	100000
90.0	100002.45	90.0000	100000.00	*******	90.0000	100000.26	100002	100000	*******	100000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

APPENDIX H

TABULATED REFRACTION COMPARISON DATA FOR EDWARDS TYPICAL WARM DAY AFTERNOON

TABLE H-I

WEATHER DATA FOR TYPICAL WARM DAY AFTERNOON

ALTITUDE (FT)	TEMPERATURE (DEG C)	DEW POINT (DEG C)	PRESSURE (MB)	N X 10E6
2316	34.00000	1.84997	929.00000	262.69745
3000	32.00000	-.15002	903.26001	254.25128
4000	29.00000	-4.15002	891.03003	247.47284
5000	26.00000	-8.15002	857.80005	236.51797
6000	23.00000	-12.15002	819.53003	225.15683
7000	20.00000	-16.15002	794.59998	218.00351
8000	17.00000	-20.15002	768.16003	211.01862
9000	14.50000	-21.15002	739.39001	204.66995
10000	12.00000	-22.15002	713.06006	198.90247
11000	9.50000	-23.15002	688.07996	193.43057
12000	7.00000	-25.15002	663.22998	187.56149
13000	4.50000	-27.15002	639.75000	182.07138
14000	2.00001	-29.15002	617.23010	176.84204
15000	-.50000	-31.15002	594.35999	171.49615
16000	-3.00000	-33.15002	572.38000	166.37622
17000	-5.50000	-36.15002	551.87000	161.49234
18000	-8.00000	-39.15002	531.03003	156.53363
19000	-10.50000	-42.15002	510.69000	151.71918
20000	-13.00000	-45.15002	491.85999	147.33475
21000	-15.70001	-48.15002	473.03998	143.03632
22000	-18.40002	-51.15002	454.40997	138.74869
23000	-21.30002	-54.15002	437.02002	134.89230
24000	-24.00003	-57.15002	420.14001	131.02570
25000	-26.70001	-60.15002	403.20001	127.07535
26000	-29.50003	-64.15002	387.12000	123.36671
27000	-32.30000	-68.14999	372.11011	119.93466
28000	-35.10002	-72.15001	356.70007	116.30334
29000	-37.90002	-76.15002	341.96997	112.81746
30000	-40.70001	-80.15002	328.31000	109.60959
31000	-40.67321	-78.92619	328.18799	109.49875
32000	-43.26289	-78.77321	315.28833	106.24097
33000	-47.19596	-79.23215	296.06165	101.44191
34000	-51.19937	-79.84407	276.95868	96.70723
35000	-54.00003	-80.15002	264.42999	93.64259
36000	-56.30975	-80.15002	255.89999	91.58688
37000	-59.35925	-80.15002	245.22552	88.96097
38000	-62.65390	-80.15002	233.50607	85.99347
39000	-65.69904	-80.15002	221.84106	82.91298
40000	-68.00003	-80.15002	211.32999	79.94809
41000	-69.18581	-80.15002	201.81140	76.86771
42000	-69.44051	-80.15002	192.46701	73.42751
43000	-69.10233	-80.15002	183.41089	69.83629
44000	-68.50945	-80.15002	174.75720	66.30289
45000	-68.00003	-80.15002	166.62000	63.03609
46000	-67.35915	-80.15002	158.83591	59.92341
47000	-66.26350	-80.15002	151.21689	56.76656
48000	-64.88873	-80.15002	143.84003	53.64563
49000	-63.41046	-80.15002	136.78241	50.64070
50000	-62.00433	-80.15002	130.12112	47.83187

TABLE H-I -- Continued

WEATHER DATA FOR TYPICAL WARM DAY AFTERNOON

ALTITUDE (FT)	TEMPERATURE (DEG C)	DEW POINT (DEG C)	PRESSURE (MB)	N X 10E6
51000	-60.56895	-80.15002	123.71893	45.17155
52000	-58.98966	-80.15002	117.44495	42.58508
53000	-57.42764	-80.15002	111.38992	40.11436
54000	-56.04404	-80.15002	105.64471	37.80131
55000	-55.00003	-80.15002	100.30000	35.68780
56000	-54.47746	-80.15002	95.31410	33.79884
57000	-54.41688	-80.15002	90.58319	32.10184
58000	-54.61759	-80.15002	86.10529	30.55256
59000	-54.87888	-80.15002	81.87820	29.10661
60000	-55.00003	-80.15002	77.89999	27.71970
61000	-54.98045	-80.15002	74.13089	26.37768
62000	-54.96028	-80.15002	70.53699	25.09793
63000	-54.94990	-80.15002	67.12457	23.88339
64000	-54.95969	-80.15002	63.90015	22.73705
65000	-55.00003	-80.15002	60.87000	21.66182
66000	-55.07311	-80.15002	58.00195	20.64641
67000	-55.14839	-80.15002	55.26201	19.67670
68000	-55.18713	-80.15002	52.65412	18.75158
69000	-55.15058	-80.15002	50.18214	17.86984
70000	-55.00003	-80.15002	47.85000	17.03036
71000	-54.62611	-80.15002	45.62428	16.21456
72000	-54.02283	-80.15002	43.47842	15.41321
73000	-53.30652	-80.15002	41.42638	14.63907
74000	-52.59348	-80.15002	39.48225	13.90495
75000	-52.00003	-80.15002	37.66000	13.22361
76000	-51.53118	-80.15002	35.93859	12.59022
77000	-51.10735	-80.15002	34.29008	11.99045
78000	-50.71793	-80.15002	32.71828	11.42289
79000	-50.35236	-80.15002	31.22698	10.88610
80000	-50.00003	-80.15002	29.82000	10.37866
81000	-49.62761	-80.15002	28.47564	9.89296
82000	-49.20585	-80.15002	27.17604	9.42399
83000	-48.73029	-80.15002	25.93060	8.97419
84000	-48.19650	-80.15002	24.74878	8.54601
85000	-47.60004	-80.15002	23.64000	8.14192
86000	-46.86880	-80.15002	22.58916	7.75574
87000	-46.01745	-80.15002	21.57758	7.38245
88000	-45.17173	-80.15002	20.60943	7.02622
89000	-44.45734	-80.15002	19.68884	6.69122
90000	-44.00003	-80.15002	18.82000	6.38161
91000	-43.87155	-80.15002	18.02932	6.10960
92000	-43.63983	-80.15002	17.15881	5.81004
93000	-42.94996	-80.15002	16.22529	5.47901
94000	-42.11295	-80.15002	15.44332	5.19646
95000	-41.53740	-80.15002	14.95721	5.01962
96000	-41.17400	-80.15002	14.63868	4.90530
97000	-40.48238	-80.15002	14.12607	4.72159
98000	-39.56448	-80.15002	13.48358	4.49147
99000	-38.53429	-80.15002	12.78299	4.24069
100000	-37.50578	-80.15002	12.09601	3.99496

COMPARISON OF GRADIENT (GMD), WHITE SANDS (CYBER) AND SPHERICAL SLAB (VARIAN) CORRECTION METHODS

BASED ON RESULTS OF GRADIENT REFRACTION SOLUTION FOR THE SAME MEASURED EL ANGLES AS USED IN JSC INTERNAL NOTE 75-FM-60

WEATHER DATA FOR TYPICAL WARM DAY AFTERNOON SEA LEVEL INDEX OF REFRACTION: .0002866 SCALE HEIGHT: 7406.42 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	129606.46	-.1397	129570.78	-.1487	-.1420	129563.38	1317	1000	980	995
.5	75503.79	.4201	75483.35	.4172	.4172	75482.15	1106	1000	997	996
1.0	49040.63	.9486	49027.43	.9469	.9488	49027.15	1044	1000	999	1000
1.5	35341.99	1.4632	35332.49	1.4619	1.4638	35332.44	1023	1000	1000	1000
2.0	27368.69	1.9717	27361.34	1.9706	1.9719	27361.35	1014	1000	1000	1000
2.5	22247.38	2.4771	22241.41	2.4761	2.4769	22241.44	1009	1000	1000	1000
3.0	18708.64	2.9809	18703.62	2.9799	2.9803	18703.64	1006	1000	1000	1000
3.5	16127.28	3.4836	16122.96	3.4827	3.4830	16122.98	1005	1000	1000	1000
4.0	14165.40	3.9857	14161.60	3.9848	3.9852	14161.61	1004	1000	1000	1000
4.5	12625.89	4.4874	12622.50	4.4865	4.4874	12622.51	1003	1000	1000	1000
5.0	11386.63	4.9887	11383.58	4.9878	4.9882	11383.58	1002	1000	1000	1000
6.0	9516.76	5.9907	9514.20	5.9898	5.9901	9514.21	1002	1000	1000	1000
7.0	8174.55	6.9921	8172.36	6.9913	6.9915	8172.36	1001	1000	1000	1000
8.0	7164.81	7.9932	7162.89	7.9924	7.9925	7162.89	1001	1000	1000	1000
9.0	6378.38	8.9940	6376.67	8.9932	8.9934	6376.67	1001	1000	1000	1000
10.0	5748.75	9.9947	5747.21	9.9939	9.9940	5747.21	1001	1000	1000	1000
12.0	4804.37	11.9957	4803.09	11.9950	11.9950	4803.09	1001	1000	1000	1000
14.0	4130.48	13.9964	4129.37	13.9957	13.9958	4129.37	1001	1000	1000	1000
16.0	3626.06	15.9970	3625.09	15.9963	15.9963	3625.09	1000	1000	1000	1000
18.0	3234.84	17.9974	3233.97	17.9967	17.9967	3233.97	1000	1000	1000	1000
20.0	2923.11	19.9977	2922.32	19.9971	19.9971	2922.32	1000	1000	1000	1000
25.0	2366.03	24.9983	2365.40	24.9977	24.9977	2365.40	1000	1000	1000	1000
30.0	1999.97	29.9988	1999.44	29.9981	29.9982	1999.44	1000	1000	1000	1000
35.0	1743.57	34.9990	1743.10	34.9985	34.9985	1743.10	1000	1000	1000	1000
40.0	1555.94	39.9992	1555.52	39.9987	39.9987	1555.52	1000	1000	1000	1000
45.0	1414.48	44.9994	1414.10	44.9989	44.9989	1414.10	1000	1000	1000	1000
50.0	1305.53	49.9996	1305.18	49.9991	49.9991	1305.18	1000	1000	1000	1000
60.0	1154.86	59.9997	1154.55	59.9994	59.9994	1154.55	1000	1000	1000	1000
70.0	1064.35	69.9998	1064.07	69.9996	69.9996	1064.07	1000	1000	1000	1000
80.0	1015.61	79.9999	1015.34	79.9998	79.9998	1015.34	1000	1000	1000	1000
90.0	1000.19	90.0000	999.92	90.0000	90.0000	999.92	1000	1000	1000	1000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

COMPARISON OF GRADIENT (GMD), WHITE SANDS (CYBER) AND SPHERICAL SLAB (VARIAN) CORRECTION METHODS

BASED ON RESULTS OF GRADIENT REFRACTION SOLUTION FOR THE SAME MEASURED EL ANGLES AS USED IN JSC INTERNAL NOTE 75-FM-60

WEATHER DATA FOR TYPICAL WARM DAY AFTERNOON SEA LEVEL INDEX OF REFRACTION: .0002866 SCALE HEIGHT: 7406.42 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	182767.91	-.1935	182719.38	-.2097	-.1957	182715.07	2618	2000	1949	1993
.5	123608.97	.3724	123577.03	.3681	.3667	123575.27	2276	2000	1992	1988
1.0	87856.95	.9104	87834.49	.9090	.9116	87834.05	2138	2000	1999	2002
1.5	66256.26	1.4329	66239.42	1.4322	1.4350	66239.41	2078	2000	2000	2003
2.0	52525.67	1.9470	52512.35	1.9466	1.9484	52512.47	2049	2000	2000	2001
2.5	43258.71	2.4566	43247.76	2.4562	2.4570	43247.89	2033	2000	2000	2000
3.0	36664.92	2.9633	36655.63	2.9630	2.9631	36655.76	2024	2000	2000	2000
3.5	31765.63	3.4683	31757.60	3.4680	3.4679	31757.70	2018	2000	2000	2000
4.0	27996.50	3.9722	27989.41	3.9718	3.9721	27989.50	2014	2000	2000	2000
4.5	25013.54	4.4752	25007.22	4.4748	4.4760	25007.28	2011	2000	2000	2000
5.0	22597.94	4.9777	22592.23	4.9773	4.9779	22592.28	2009	2000	2000	2000
6.0	18930.73	5.9815	18925.94	5.9810	5.9813	18925.97	2007	2000	2000	2000
7.0	16283.64	6.9842	16279.53	6.9837	6.9839	16279.55	2005	2000	2000	2000
8.0	14285.94	7.9863	14282.33	7.9857	7.9858	14282.35	2004	2000	2000	2000
9.0	12725.89	8.9879	12722.68	8.9873	8.9874	12722.69	2003	2000	2000	2000
10.0	11475.00	9.9891	11472.11	9.9886	9.9886	11472.12	2003	2000	2000	2000
12.0	9595.69	11.9911	9593.26	11.9905	11.9905	9593.27	2002	2000	2000	2000
14.0	8252.76	13.9925	8250.67	13.9919	13.9919	8250.68	2002	2000	2000	2000
16.0	7246.68	15.9935	7244.84	15.9930	15.9929	7244.85	2001	2000	2000	2000
18.0	6466.04	17.9944	6464.41	17.9938	17.9938	6464.41	2001	2000	2000	2000
20.0	5843.46	19.9950	5841.99	19.9945	19.9944	5841.99	2001	2000	2000	2000
25.0	4730.71	24.9962	4729.51	24.9957	24.9957	4729.52	2001	2000	2000	2000
30.0	3999.35	29.9970	3998.34	29.9965	29.9965	3998.34	2001	2000	2000	2000
35.0	3486.84	34.9976	3485.96	34.9971	34.9971	3485.97	2001	2000	2000	2000
40.0	3111.57	39.9981	3110.79	39.9976	39.9976	3110.79	2001	2000	2000	2000
45.0	2828.75	44.9984	2828.03	44.9980	44.9980	2828.04	2001	2000	2000	2000
50.0	2611.10	49.9987	2610.44	49.9983	49.9983	2610.45	2000	2000	2000	2000
60.0	2309.82	59.9991	2309.24	59.9988	59.9988	2309.24	2000	2000	2000	2000
70.0	2128.84	69.9995	2128.30	69.9993	69.9993	2128.30	2000	2000	2000	2000
80.0	2031.20	79.9998	2030.69	79.9996	79.9996	2030.69	2000	2000	2000	2000
90.0	2000.36	90.0000	1999.85	90.0000	90.0000	1999.85	2000	2000	2000	2000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

COMPARISON OF GRADIENT (GMD), WHITE SANDS (CYBER) AND SPHERICAL SLAB (VARIAN) CORRECTION METHODS

BASED ON RESULTS OF GRADIENT REFRACTION SOLUTION FOR THE SAME MEASURED EL ANGLES AS USED IN JSC INTERNAL NOTE 75-FM-60

WEATHER DATA FOR TYPICAL WARM DAY AFTERNOON SEA LEVEL INDEX OF REFRACTION: .0002866 SCALE HEIGHT: 7406.42 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	286733.95	-.2878	286664.61	-.3290	-.2413	286668.78	6442	5000	4797	5233
.5	222897.48	.2851	222846.01	.2749	.2860	222845.58	5837	5000	4962	5003
1.0	176325.55	.8339	176285.87	.8335	.8389	176286.34	5512	5000	5000	5015
1.5	142736.57	1.3674	142704.93	1.3702	1.3736	142705.86	5331	5000	5008	5015
2.0	118346.81	1.8911	118320.80	1.8947	1.8959	118321.83	5226	5000	5009	5010
2.5	100301.38	2.4082	100279.45	2.4119	2.4112	100280.43	5162	5000	5008	5005
3.0	86632.45	2.9211	86613.57	2.9246	2.9226	86614.42	5120	5000	5007	5002
3.5	76028.29	3.4310	76011.76	3.4343	3.4319	76012.49	5093	5000	5006	5001
4.0	67617.24	3.9388	67602.56	3.9418	3.9404	67603.18	5073	5000	5005	5002
4.5	60812.17	4.4451	60798.99	4.4478	4.4484	60799.51	5059	5000	5004	5004
5.0	55209.80	4.9503	55197.84	4.9528	4.9535	55198.28	5049	5000	5004	5003
6.0	46559.91	5.9583	46549.84	5.9604	5.9602	46550.17	5035	5000	5003	5002
7.0	40217.27	6.9641	40208.57	6.9659	6.9653	40208.84	5026	5000	5002	5001
8.0	35381.29	7.9686	35373.64	7.9701	7.9693	35373.87	5020	5000	5002	5000
9.0	31578.99	8.9721	31572.17	8.9734	8.9726	31572.37	5016	5000	5002	5000
10.0	28514.93	9.9750	28508.77	9.9761	9.9752	28508.96	5013	5000	5002	5000
12.0	23888.82	11.9793	23883.66	11.9801	11.9793	23883.82	5010	5000	5001	5000
14.0	20568.67	13.9824	20564.23	13.9830	13.9823	20564.37	5007	5000	5001	5000
16.0	18074.63	15.9847	18070.73	15.9852	15.9845	18070.86	5006	5000	5001	5000
18.0	16135.69	17.9866	16132.21	17.9869	17.9863	16132.32	5005	5000	5001	5000
20.0	14587.44	19.9880	14584.29	19.9883	19.9878	14584.39	5004	5000	5001	5000
25.0	11816.33	24.9908	11813.79	24.9909	24.9904	11813.87	5003	5000	5001	5000
30.0	9992.57	29.9926	9990.41	29.9926	29.9923	9990.49	5002	5000	5001	5000
35.0	8713.37	34.9940	8711.49	34.9939	34.9936	8711.55	5002	5000	5001	5000
40.0	7776.72	39.9950	7775.05	39.9949	39.9947	7775.10	5002	5000	5001	5000
45.0	7070.29	44.9958	7068.76	44.9957	44.9955	7068.81	5001	5000	5001	5000
50.0	6526.90	49.9965	6525.50	49.9964	49.9962	6525.54	5001	5000	5001	5000
60.0	5774.07	59.9977	5772.83	59.9975	59.9974	5772.87	5001	5000	5001	5000
70.0	5321.71	69.9985	5320.57	69.9985	69.9984	5320.61	5001	5000	5001	5000
80.0	5078.12	79.9993	5077.03	79.9993	79.9992	5077.07	5001	5000	5001	5000
90.0	5001.04	90.0000	4999.96	90.0000	90.0000	5000.00	5001	5000	5001	5000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

COMPARISON OF GRADIENT (GMD), WHITE SANDS (CYBER) AND SPHERICAL SLAB (VARIAN) CORRECTION METHODS

BASED ON RESULTS OF GRADIENT REFRACTION SOLUTION FOR THE SAME MEASURED EL ANGLES AS USED IN JSC INTERNAL NOTE 75-FM-60

WEATHER DATA FOR TYPICAL WARM DAY AFTERNOON SEA LEVEL INDEX OF REFRACTION: .0002866 SCALE HEIGHT: 7406.42 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	401494.96	-.3745	401409.34	-.4606	-.2665	401423.45	12624	10000	9402	10756
.5	335350.98	.2043	335284.04	.1806	.2547	335288.67	11732	10000	9865	10295
1.0	282648.81	.7598	282594.76	.7589	.7938	282598.79	11186	10000	9998	10167
1.5	240803.34	1.3004	240758.58	1.3083	1.3253	240762.37	10840	10000	10036	10105
2.0	207587.03	1.8308	207549.18	1.8420	1.8490	207552.68	10614	10000	10043	10066
2.5	181100.35	2.3542	181067.75	2.3662	2.3671	181070.89	10462	10000	10040	10041
3.0	159801.25	2.8725	159772.75	2.8844	2.8816	159775.51	10357	10000	10035	10026
3.5	142488.40	3.3870	142463.16	3.3985	3.3942	142465.56	10282	10000	10030	10018
4.0	128250.19	3.8989	128227.58	3.9097	3.9061	128229.67	10227	10000	10026	10016
4.5	116401.59	4.4086	116381.15	4.4187	4.4179	116382.98	10187	10000	10022	10019
5.0	106428.91	4.9167	106410.27	4.9262	4.9264	106411.89	10156	10000	10019	10018
6.0	90658.14	5.9295	90642.33	5.9378	5.9362	90643.62	10113	10000	10015	10011
7.0	78821.35	6.9390	78807.63	6.9463	6.9440	78808.73	10085	10000	10012	10007
8.0	69653.44	7.9464	69641.34	7.9528	7.9503	69642.30	10066	10000	10010	10005
9.0	62365.49	8.9522	62354.67	8.9580	8.9553	62355.54	10053	10000	10008	10004
10.0	56445.39	9.9569	56435.60	9.9621	9.9595	56436.41	10043	10000	10007	10003
12.0	47434.68	11.9642	47426.47	11.9685	11.9660	47427.16	10031	10000	10005	10002
14.0	40920.31	13.9694	40913.23	13.9731	13.9708	40913.84	10023	10000	10004	10001
16.0	36003.90	15.9734	35997.67	15.9766	15.9745	35998.21	10018	10000	10004	10001
18.0	32169.66	17.9765	32164.10	17.9793	17.9775	32164.59	10014	10000	10003	10001
20.0	29101.08	19.9791	29096.05	19.9815	19.9798	29096.50	10012	10000	10003	10000
25.0	23595.72	24.9837	23591.64	24.9855	24.9842	23592.00	10008	10000	10002	10000
30.0	19964.53	29.9869	19961.08	29.9883	29.9872	19961.38	10006	10000	10002	10000
35.0	17414.33	34.9892	17411.32	34.9904	34.9894	17411.59	10004	10000	10002	10000
40.0	15545.48	39.9911	15542.80	39.9920	39.9912	15543.04	10004	10000	10002	10000
45.0	14135.31	44.9925	14132.86	44.9932	44.9926	14133.08	10003	10000	10002	10000
50.0	13050.32	49.9937	13048.06	49.9943	49.9938	13048.26	10003	10000	10002	10000
60.0	11546.42	59.9957	11544.42	59.9961	59.9957	11544.60	10002	10000	10002	10000
70.0	10642.65	69.9973	10640.81	69.9975	69.9973	10640.97	10002	10000	10002	10000
80.0	10155.75	79.9987	10153.99	79.9988	79.9987	10154.15	10002	10000	10002	10000
90.0	10001.68	90.0000	9999.95	90.0000	90.0000	10000.11	10002	10000	10002	10000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

COMPARISON OF GRADIENT (GMD), WHITE SANDS (CYBER) AND SPHERICAL SLAB (VARIAN) CORRECTION METHODS

BASED ON RESULTS OF GRADIENT REFRACTION SOLUTION FOR THE SAME MEASURED EL ANGLES AS USED IN JSC INTERNAL NOTE 75-FM-60

WEATHER DATA FOR TYPICAL WARM DAY AFTERNOON SEA LEVEL INDEX OF REFRACTION: .0002866 SCALE HEIGHT: 7406.42 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	559774.64	-.4632	559678.32	-.6422	-.3164	559700.37	24517	20000	18263	21431
.5	492092.93	.1228	492016.02	.0657	.2104	492024.78	23235	20000	19518	20751
1.0	435052.75	.6847	434989.37	.6739	.7485	434996.57	22391	20000	19923	20483
1.5	386743.62	1.2313	386690.16	1.2402	1.2799	386696.53	21812	20000	20064	20328
2.0	345759.01	1.7673	345713.07	1.7849	1.8048	345718.78	21403	20000	20110	20226
2.5	310935.97	2.2958	310895.88	2.3170	2.3246	310900.95	21107	20000	20118	20156
3.0	281277.07	2.8188	281241.64	2.8411	2.8412	281246.10	20889	20000	20112	20110
3.5	255927.68	3.3376	255896.02	3.3599	3.3562	255899.94	20725	20000	20102	20083
4.0	234164.56	3.8532	234135.99	3.8748	3.8709	234139.45	20600	20000	20091	20072
4.5	215383.80	4.3663	215357.82	4.3870	4.3858	215360.89	20503	20000	20080	20073
5.0	199086.39	4.8774	199062.59	4.8971	4.8965	199065.33	20426	20000	20071	20066
6.0	172377.72	5.8951	172357.38	5.9129	5.9097	172359.63	20315	20000	20056	20044
7.0	151577.18	6.9087	151559.46	6.9246	6.9203	151561.40	20242	20000	20044	20031
8.0	135032.39	7.9193	135016.71	7.9337	7.9289	135018.44	20190	20000	20036	20023
9.0	121620.85	8.9278	121606.78	8.9408	8.9360	121608.36	20153	20000	20030	20017
10.0	110565.41	9.9347	110552.67	9.9466	9.9419	110554.13	20126	20000	20025	20014
12.0	93480.82	11.9454	93470.10	11.9555	11.9511	93471.37	20089	20000	20018	20009
14.0	80951.90	13.9533	80942.64	13.9619	13.9580	80943.76	20066	20000	20014	20007
16.0	71408.16	15.9593	71400.01	15.9668	15.9632	71401.01	20051	20000	20011	20005
18.0	63917.53	17.9640	63910.24	17.9707	17.9674	63911.14	20040	20000	20009	20004
20.0	57895.56	19.9678	57888.97	19.9738	19.9708	57889.79	20033	20000	20008	20003
25.0	47037.48	24.9749	47032.13	24.9795	24.9771	47032.80	20021	20000	20006	20002
30.0	39842.82	29.9797	39838.29	29.9834	29.9815	39838.86	20014	20000	20005	20001
35.0	34776.77	34.9833	34772.82	34.9863	34.9847	34773.32	20011	20000	20004	20001
40.0	31058.15	39.9861	31054.62	39.9886	39.9872	31055.07	20008	20000	20003	20001
45.0	28249.11	44.9883	28245.91	44.9904	44.9893	28246.31	20006	20000	20003	20001
50.0	26086.14	49.9902	26083.18	49.9920	49.9910	26083.56	20005	20000	20003	20001
60.0	23086.15	59.9933	23083.53	59.9945	59.9938	23083.87	20004	20000	20002	20000
70.0	21282.13	69.9958	21279.71	69.9965	69.9961	21280.02	20003	20000	20002	20000
80.0	20309.96	79.9980	20307.66	79.9983	79.9981	20307.95	20002	20000	20002	20000
90.0	20002.26	90.0000	19999.99	90.0000	90.0000	20000.28	20002	20000	20002	20000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

COMPARISON OF GRADIENT (GMD), WHITE SANDS (CYBER) AND SPHERICAL SLAB (VARIAN) CORRECTION METHODS

BASED ON RESULTS OF GRADIENT REFRACTION SOLUTION FOR THE SAME MEASURED EL ANGLES AS USED IN JSC INTERNAL NOTE 75-FM-60

WEATHER DATA FOR TYPICAL WARM DAY AFTERNOON SEA LEVEL INDEX OF REFRACTION: .0002866 SCALE HEIGHT: 7406.42 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	864442.00	-.5550	864342.12	-.9918	-.4010	864367.16	58313	50000	43469	52305
.5	795508.26	.0428	795428.57	-.1146	.1227	795436.80	56303	50000	47839	51100
1.0	734817.55	.6140	734751.86	.5554	.6751	734758.63	54916	50000	49261	50777
1.5	680729.69	1.1679	680674.22	1.1522	1.2171	680680.23	53918	50000	49821	50579
2.0	632226.99	1.7100	632179.26	1.7148	1.7497	632184.64	53177	50000	50057	50433
2.5	588584.99	2.2436	588543.28	2.2585	2.2754	588548.05	52614	50000	50156	50322
3.0	549234.58	2.7709	549197.65	2.7908	2.7967	549201.83	52179	50000	50192	50243
3.5	513701.28	3.2935	513668.23	3.3157	3.3157	513671.88	51837	50000	50200	50197
4.0	481575.11	3.8123	481545.26	3.8353	3.8343	481548.45	51565	50000	50195	50183
4.5	452484.00	4.3283	452456.81	4.3513	4.3532	452459.63	51345	50000	50183	50195
5.0	426099.43	4.8420	426074.49	4.8645	4.8663	426077.00	51165	50000	50169	50178
6.0	380334.08	5.8640	380312.74	5.8851	5.8832	380314.78	50892	50000	50140	50125
7.0	342311.48	6.8810	342292.85	6.9004	6.8969	342294.61	50702	50000	50116	50092
8.0	310462.06	7.8944	310445.56	7.9122	7.9080	310447.14	50564	50000	50096	50071
9.0	283556.09	8.9053	283541.28	8.9216	8.9171	283542.73	50461	50000	50081	50057
10.0	260629.66	9.9142	260616.23	9.9292	9.9247	260617.59	50384	50000	50069	50046
12.0	223864.19	11.9280	223852.88	11.9409	11.9365	223854.07	50274	50000	50050	50031
14.0	195903.55	13.9382	195893.78	13.9494	13.9454	195894.83	50204	50000	50038	50022
16.0	174066.69	15.9460	174058.08	15.9559	15.9522	174059.03	50157	50000	50029	50017
18.0	156620.29	17.9522	156612.60	17.9610	17.9577	156613.45	50124	50000	50024	50013
20.0	142411.16	19.9572	142404.20	19.9651	19.9621	142404.98	50101	50000	50020	50010
25.0	116411.37	24.9665	116405.72	24.9727	24.9703	116406.36	50063	50000	50014	50007
30.0	98941.59	29.9729	98936.81	29.9779	29.9759	98937.36	50042	50000	50009	50004
35.0	86541.28	34.9777	86537.11	34.9818	34.9801	86537.59	50029	50000	50007	50002
40.0	77392.86	39.9814	77389.14	39.9848	39.9834	77389.57	50021	50000	50005	50001
45.0	70458.83	44.9843	70455.44	44.9872	44.9860	70455.83	50015	50000	50004	50001
50.0	65107.07	49.9869	65103.94	49.9893	49.9883	65104.30	50011	50000	50003	50001
60.0	57667.79	59.9910	57665.02	59.9926	59.9919	57665.34	50006	50000	50003	50000
70.0	53185.73	69.9943	53183.18	69.9954	69.9949	53183.48	50004	50000	50003	50000
80.0	50768.00	79.9972	50765.57	79.9977	79.9975	50765.85	50003	50000	50002	50000
90.0	50002.40	90.0000	50000.00	90.0000	90.0000	50000.28	50002	50000	50002	50000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

COMPARISON OF GRADIENT (GMD), WHITE SANDS (CYBER) AND SPHERICAL SLAB (VARIAN) CORRECTION METHODS

BASED ON RESULTS OF GRADIENT REFRACTION SOLUTION FOR THE SAME MEASURED EL ANGLES AS USED IN JSC INTERNAL NOTE 75-FM-60

WEATHER DATA FOR TYPICAL WARM DAY AFTERNOON SEA LEVEL INDEX OF REFRACTION: .0002866 SCALE HEIGHT: 7406.42 METERS

INPUT DATA		GMD GRAD REF SOL		CYBER	SPHERICAL SLAB		ALTITUDE COMPUTED BY EACH SOLUTION METHOD			
E MEAS DEG	R MEAS METER	E COR DEG	R COR METER	E COR DEG	E COR DEG	R COR METER	NO CORR METER	GMD H METER	CYB H METER	VAR H METER
0.0	1203073.35	-.6031	1202972.38	-1.3803	-.4511	1202998.47	112472	100000	83932	103145
.5	1133543.53	.0035	1133463.21	-.2690	.0695	1133470.67	109677	100000	94703	101285
1.0	1071088.79	.5810	1071022.72	.4672	.6331	1071029.01	107718	100000	97916	100959
1.5	1014120.78	1.1397	1014065.07	1.0926	1.1831	1014070.79	106263	100000	99188	100757
2.0	961708.66	1.6855	961660.75	1.6703	1.7215	961665.96	105199	100000	99756	100595
2.5	913254.38	2.2220	913212.54	2.2233	2.2514	913217.19	104364	100000	100027	100461
3.0	868304.95	2.7517	868267.94	2.7617	2.7759	868272.04	103705	100000	100155	100360
3.5	826526.62	3.2761	826493.51	3.2908	3.2976	826497.09	103177	100000	100213	100302
4.0	787649.73	3.7966	787619.82	3.8137	3.8184	787622.97	102750	100000	100235	100293
4.5	751438.57	4.3139	751411.34	4.3321	4.3394	751414.12	102400	100000	100239	100329
5.0	717677.32	4.8287	717652.35	4.8473	4.8539	717654.82	102109	100000	100233	100310
6.0	656782.07	5.8525	656760.71	5.8707	5.8727	656762.72	101658	100000	100207	100225
7.0	603670.82	6.8709	603652.18	6.8880	6.8877	603653.92	101332	100000	100179	100172
8.0	557223.77	7.8854	557207.26	7.9014	7.8998	557208.82	101090	100000	100155	100137
9.0	516458.97	8.8971	516444.16	8.9119	8.9098	516445.60	100903	100000	100131	100110
10.0	480579.16	9.9068	480565.73	9.9205	9.9181	480567.07	100761	100000	100114	100092
12.0	420715.63	11.9218	420704.31	11.9336	11.9310	420705.49	100555	100000	100085	100064
14.0	373221.92	13.9328	373212.15	13.9431	13.9407	373213.19	100420	100000	100066	100048
16.0	334935.91	15.9413	334927.31	15.9504	15.9481	334928.25	100326	100000	100052	100036
18.0	303615.44	17.9480	303607.75	17.9561	17.9540	303608.59	100261	100000	100043	100030
20.0	277629.43	19.9535	277622.47	19.9608	19.9588	277623.24	100210	100000	100034	100023
25.0	229058.91	24.9635	229053.25	24.9693	24.9677	229053.69	100132	100000	100022	100014
30.0	195737.81	29.9705	195733.03	29.9752	29.9738	195733.57	100087	100000	100015	100009
35.0	171785.04	34.9756	171780.86	34.9795	34.9784	171781.34	100060	100000	100011	100006
40.0	153968.31	39.9797	153964.59	39.9829	39.9819	153965.02	100043	100000	100008	100004
45.0	140389.01	44.9829	140385.63	44.9856	44.9848	140386.01	100031	100000	100006	100003
50.0	129868.58	49.9857	129865.45	49.9880	49.9873	129865.81	100023	100000	100006	100003
60.0	115188.11	59.9901	115185.35	59.9917	59.9912	115185.66	100012	100000	100004	100001
70.0	106315.69	69.9938	106313.14	69.9948	69.9945	106313.44	100006	100000	100003	100001
80.0	101521.61	79.9970	101519.18	79.9975	79.9973	101519.46	100003	100000	100002	100000
90.0	100002.40	90.0000	100000.00	90.0000	90.0000	100000.28	100002	100000	100002	100000

***** INDICATES INPUT VALUES HAVE EXCEEDED THE COMPUTATIONAL LIMITS OF THE SOLUTION METHOD

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA CR-166616		

4. Title and Subtitle	5. Report Date
Mathematical Analysis Study for Radar Data Processing and Enhancement Part II: Modeling of Propagation Path Errors	August 1985
	6. Performing Organization Code
7. Author(s) Robert James and James D. Brownlow	8. Performing Organization Report No. H-1287
	10. Work Unit No. RTOP 506-51-11
9. Performing Organization Name and Address GMD Systems 45303 N. Twenty-third St. West Lancaster, California 93534	11. Contract or Grant No. NAS2-11491
	13. Type of Report and Period Covered Contractor Report – Final
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, D.C. 20546	14. Sponsoring Agency Code

15. Supplementary Notes

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16. Abstract

A study was performed under NASA contract to evaluate data from an AN/FPS-16 radar installed for support of flight programs at Dryden Flight Research Facility of NASA Ames Research Center. The purpose of this study was to provide information necessary for improving post-flight data reduction and knowledge of accuracy of derived radar quantities. Tracking data from six flights were analyzed. Noise and bias errors in raw tracking data were determined for each of the flights. A discussion of an altitude bias error during all of the tracking missions is included. This bias error was defined by utilizing pressure altitude measurements made during "survey flights." Four separate filtering methods, representative of the most widely used optimal estimation techniques for enhancement of radar tracking data, were analyzed for suitability in processing both real-time and post-mission data. Additional information regarding the radar and its measurements, including typical noise and bias errors in the range and angle measurements, is also presented. Part I of this report is an analysis of radar data; part II is a discussion of the modeling of propagation path errors.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
Atmospheric refraction Data filtering Radar calibration Radar systems Tracking data processing	Unclassified – Unlimited STAR category 17

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*
Unclassified	Unclassified	120	A06

For sale by the National Technical Information Service, Springfield, Virginia 22161.

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